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IMPROVEMENT OF THE IBM 1620 SPS PROCESSOR

THESIS

GE/EE/62-5 Leland G. Fay
Capt USAF

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Preface

The selection of this thesis project came as a result of an interest in the growing importance of computer programming in the fields of weapon system development and operations research. When this topic was brought to my attention by Professor C. H. Houpis it seemed like an excellent opportunity to become familiar with the problems involved in the application of computer programming techniques to these fields.

The excellent facilities available at Wright Field made the preparation of this thesis substantially easier. Of particular importance were the 7090 Data Processing System and the auxiliary input/output equipment that were used for numerous assemblies of my computer program. By their willingness to cooperate in the use of their equipment the personnel of the Analysis Branch, ASNCDA contributed immeasurably to this project.

A great deal of thanks goes to Lt. Richard L. Pratt, my faculty advisor, for all his assistance and encouragement in the preparation of this thesis. Only through his guidance was I able to learn in sufficient time the fundamentals of computer programming and analysis that enabled me to conduct an independent research in this area. His suggestions and knowledge of computer programming saved me many hours of lost labor

and effort throughout the thesis investigation.

Special thanks go...to my wife for her patience throughout the past year and a half and for typing this thesis...and to my children for their hours of forgone "playtimes".

And last is a vote of confidence to the AFIT 1620 computer which has been my constant companion (friend and foe) throughout these past five months.

Leland G. Fay

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Abstract

The IBM 1620 SPS Processor Program is examined to determine the possibility of shortening the program and of increasing the capability of the processor. SPS programming and coding techniques used to accomplish these ends are described and illustrated. Program checkout procedures are explained and the modified processor is redesignated the AFIT Version of the 1620 SPS Processor. Operating instructions and a listing of the program are included.

IMPROVEMENT OF THE IBM 1620 SPS PROCESSOR

I. Introduction

The purpose of this thesis project is to improve the IBM 1620 SPS Processor Program. A full appreciation of the problems encountered in this study requires complete familiarity with the IBM 1620 Data Processing System and the IBM 1620/1710 Symbolic Programming System. No attempt will be made to present a detailed breakdown of these systems, but those system aspects central to the problem under investigation will be discussed in context.

The IBM 1620 Data Processing System is a small electronic digital computer system designed for technical and scientific applications. For the purposes of this investigation the configuration of this system will include the IBM 1620 Central Processing Unit, and the IBM 1622 Card Read-Punch Unit which provides the punched card input and output for the processing system.

One of the programming systems designed for the IBM 1620 Data Processing System has been designated the 1620/1710 Symbolic Programming System. The complete system consists of the symbolic language used by the programmer in writing a source program, the library of subroutines and linkage instructions, and the processor

program which translates the symbolic language used by the programmer into the operating machine language of the 1620 (Ref 5:5).

This thesis investigation concerns itself with the modification of the processor program only.

The criteria established for the improvement of the IBM SPS Processor program were that the processor program would (1) occupy less space in core storage, and (2) have an increased performance capability. The adoption of these criteria resolved the thesis study into four major areas of investigation. These were:

1. To shorten the SPS Processor program so that it would occupy less memory storage space without reducing the capability of the processor.
2. To increase the capability of the SPS processor by incorporating the necessary coded routines or modifications into the processor program.
3. To perform a functional and operational checkout of the modified processor program using standard computer procedures.
4. To prepare a compiled list of operating procedures for the modified processor program for use with the 1620 computer facility at the Institute of Technology.

Since the importance of this study rests on the results achieved and the methodology employed, the thesis has been divided into chapters, each reflecting a particular aspect of the methods and techniques employed in this investigation.

Chapter two defines the terms and concepts most frequently used in this report. It includes a functional and operational description of 1620 Data Representation, the Symbolic Programming System and the SPS Processor.

Chapter three describes the basic programming process and associated equipment that was utilized in modifying the IBM 1620 SPS Processor Program.

Chapter four consists of two parts. Part one describes the concepts, methods and coding techniques employed to shorten the IBM SPS Processor Program. Part two outlines the computer programming and coding techniques utilized to increase the capability of the SPS processor.

Chapter five outlines the checkout procedures and techniques that were used to test the modified program.

Chapter six is a summary of the results obtained by employing the methods and techniques outlined in the preceding chapters. This chapter essentially itemizes the major improvements and modifications incorporated into the AFIT Version of the SPS Processor Program.

The appendix contains a compiled set of operating instructions and a detailed description of the AFIT Version of the 1620 SPS Processor Program. A label reference index and a program listing of the AFIT Version of 1620 SPS are also included.

The thesis as outlined above essentially provides a step by step analysis of the procedures, methods, and techniques of computer analysis and programming that led to the improvement of the IBM 1620 SPS Processor Program and resulted in the AFIT Version of 1620 SPS.

II. Terminology

This chapter is intended to serve as a reference for the terms and concepts utilized throughout the remainder of this thesis report. Those persons thoroughly familiar with the Symbolic Programming System and the 1620 Data Processing System may desire to proceed directly to chapter III.

This chapter will discuss three topics - 1620 Data Representation, the Symbolic Programming System, and Processor Operation.

1620 Data Representation

Instruction Format. A 12-digit machine language instruction consisting of a 2-digit operation (OP) code, a 5-digit "P" address and a 5-digit "Q" address is used in the IBM 1620. The core storage format of the instruction is illustrated in Figure 1 (Ref 6:11).

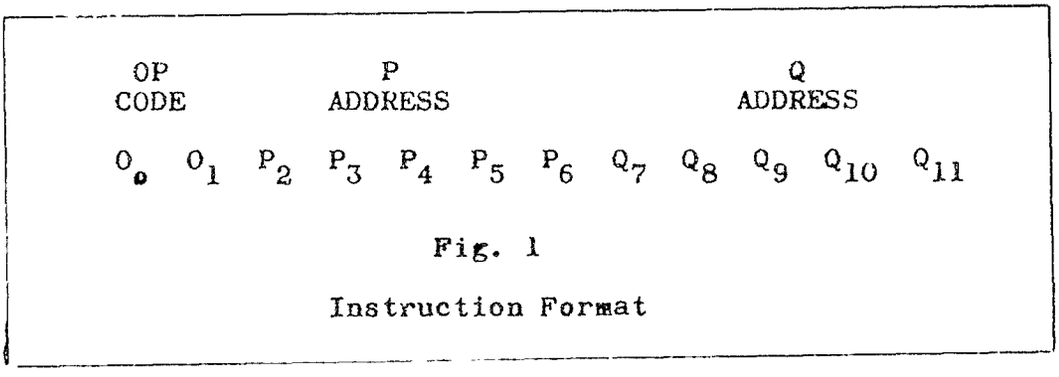

Fig. 1

Instruction Format

Data Fields. All data can be classified as digits, fields or records, depending on the manner in which they are addressed. Each core storage position is addressable and can store one digit of information. A field consists of a number of consecutively addressed digits that are processed from right to left until terminated by a flag bit.

Field

$\overline{X}\ X\ .\ .\ .\ .\ .\ .\ X$

Flag Bit (End of Field)

Addressed Digit (Highest Numbered Core Storage Position)

A record consists of a field or fields of data that are grouped for transmission. Internal records are processed from left to right until terminated by a record mark.

Operation Mode. The IBM 1620 can operate in either the numeric or alphameric mode when reading or writing data; the mode is designated by the input/output instruction. In the alphameric mode two digits of core storage are required to represent a character. Figure 2 shows the digits that are assigned to represent the alphameric characters used in the 1620. Use of the alphameric mode of operation permits program statements to be written in a symbolic language more meaningful and easier to handle than the numerical machine language (Ref 6:7-8).

Two-Digit Representation		Alphameric Character	
	00	b	
	03	.	
	04	)	
	10	+	
	13	$	
	14	*	
	20	-	
	21	/	
	23	'	
	24	(	
	33	=	
	34	@	
	41	A	
	42	B	
	43	C	
	44	D	
	45	E	
	46	F	
	47	G	
	48	H	
	49	I	
	50	Ō	Minus 0 through 9
	51	J	
	52	K	
	53	L	
	54	M	
	55	N	
	56	O	
	57	P	
	58	Q	
	59	R	
	62	S	
	63	T	
	64	U	
	65	V	
	66	W	
	67	X	
	68	Y	
	69	Z	
	70	0	Plus or unsigned 0 through 9
	71	1	
	72	2	
	73	3	
	74	4	
	75	5	
	76	6	
	77	7	
	78	8	
	79	9	

Fig. 2

Alphameric Codes

Symbolic Programming System

The Symbolic Programming System is designed to simplify the preparation of programs for the 1620 Data Processing System. The symbolic language is the notation in which the programmer codes the program and is in the form of mnemonic operation codes and a combination of fixed and free format statements. A program written in this manner which is intended for translation into machine language is called a "source" program.

Program Statements. There are three general types of statements, which are based on the type of operation code, that comprise the source program: (1) Area Definition Statements, which correspond to declarative operation codes, are used to define work areas and input/output areas. (2) Instruction Statements, which correspond to imperative op-codes, specify the job the object program is to perform; these are classified as arithmetic, internal data transmission, branch, and program control instructions. (3) Processor Control Statements, which correspond to the control op-codes, provide the programmer with control over portions of the assembly process (Ref 18:1,3).

For convenience a functional listing of 1620 mnemonic operation codes is included in Table 1 on page 9. Table 2 on page 11 lists the unique mnemonic operation codes that are provided in the Symbolic Programming System.

Table I

Mnemonic Operation Codes

1. Area Definitions

Operation Code	Description
DS & DAS & DSS	Define Symbol
DC & DAC & DSC	Define Constant
DSA	Define Symbolic Address
DSB	Define Symbolic Block
DNB	Define Numeric Blank

2. Arithmetic Instructions

Mnemonic Operation Code	Numeric Operation Code	Description
A	21	Add
AM	11	Add Immediate
S	22	Subtract
SM	12	Subtract Immediate
C	24	Compare
CM	14	Compare Immediate
M	23	Multiply
MM	13	Multiply Immediate
LD	28	Load Dividend
LDM	18	Load Dividend Immediate
D	29	Divide
DM	19	Divide Immediate

3. Internal Data Transmission

Mnemonic Operation Code	Numeric Operation Code	Description
TD	25	Transmit Digit
MF	71	Move Flag
TDM	15	Transmit Digit Immediate
TF	26	Transmit Field
TFM	16	Transmit Field Immediate
TR	31	Transmit Record
TNS	72	Transfer Numerical Strip
TNF	73	Transfer Numerical Fill
	4. Branch Instructions	
B	49	Branch
BNF	44	Branch No Flag
BNR	45	Branch No Record Mark
BD	43	Branch on Digit
BI	46	Branch Indicator
BNI	47	Branch No Indicator
BT	27	Branch and Transmit
BTM	17	Branch and Transmit Immediate
BB	42	Branch Back
	5. Program Control Instructions	
K	34	Control
SF	32	Set Flag
CF	33	Clear Flag
H	48	Halt
NOP	47	No Operation

6. Processor Control Operation Codes

Operation Code	Description
DORG	Define Origin
HEAD	HEAD
TCD	Transfer Control and Load
TRA	Transfer to Return Address
DEND	Define END

Table II

Unique Mnemonic Operation Codes

1. Unique Input/Output Mnemonic

OP Code		Description
RNTY	Read Numerically	Typewriter
RNCD	Read Numerically	Card Reader
WNTY	Write Numerically	Typewriter
WNCD	Write Numerically	Card Punch
DNTY	Dump Numerically	Typewriter
DNCD	Dump Numerically	Card Punch
RATY	Read Alphamerically	Typewriter
RACD	Read Alphamerically	Card Reader
WATY	Write Alphamerically	Typewriter
WACD	Write Alphamerically	Card Punch
	2. Unique Typewriter Control Mnemonic	
TBTY	Tabulate	Typewriter
RCTY	Return Carriage	Typewriter
SPTY	Space	Typewriter
	3. Unique Branch Indicators	
BH	Branch High	
BE	Branch Equal	
BNN	Branch Not Negative	
BP	Branch Positive	
BZ	Branch Zero	
BV	Branch Overflow	
BXV	Branch Exponential Overflow	
BA	Branch Any	
BNL	Branch Not Low	
BC1	Branch Console Switch 1 ON	
BC2	Branch Console Switch 2 ON	
BC3	Branch Console Switch 3 ON	

3. Unique Branch Indicators (cont.)

OP Code	Description
BC4	Branch Console Switch 4 ON
BNH	Branch Not High
BNP	Branch Not Positive
BNE	Branch Not Equal
BNZ	Branch Not Zero
BNV	Branch No Overflow
BNXV	Branch No Exponential Overflow
BNA	Branch Not Any
BL	Branch Low
BN	Branch Negative
BNC1	Branch Console Switch 1 OFF
BNC2	Branch Console Switch 2 OFF
BNC3	Branch Console Switch 3 OFF
BNC4	Branch Console Switch 4 OFF
BLC	Branch Last Card
BNLC	Branch Not Last Card

Statement Format. Each statement except a comment statement may consist of a label field, an operation code field and an operands field.

A Label Field is used to associate a name with a statement to allow a symbolic reference to the statement. Only statements referred to elsewhere in the program need be labeled.

The Operation Code Field contains the actual two-digit numerical operation code or the mnemonic representation of the operation code to be performed.

The Operands Field is used to specify the information that is to be operated upon. The field will contain symbolic or absolute addresses, area sizes, instruction modifiers, or constants.

Asterisks. In order to eliminate the necessity for too many labels, an asterisk (*) is used for addressing relative to the instruction in which the asterisk is contained.

When the asterisk address is used with either area definition or control statements, it references the low order (rightmost) position of the field last defined. For example the statements

```
TFM START,0
DC  1,@,*
```

produce the instruction 1601876̃0000⁄ where START equals 01876 (Ref 5:14).

Address Adjustment. Address adjustment, which is permitted with all addresses, actual, symbolic, or asterisk, is used to direct the processor to adjust the addresses of operands arithmetically. This feature reduces the number of symbols necessary for a source program by providing a means to reference a location a given number of positions away from a specific address. For example in the statements

```
TBTY
DC 1,7,*-5
```

the address assigned the constant 7 is 5 digits less than the address of the low order position of the TBTY statement. The assembled instruction appears as 34 0000700108 (Ref 5:15).

Important Instructions. Instructions that are used quite frequently in the examples and illustrations throughout this thesis are defined below.

The Branch (B-49) instruction causes an unconditional branch to the instruction at the P address, which is the next instruction to be executed. The Q part of the instruction is not used.

The Branch and Transmit (BT-27) instruction accomplishes three things: (1) The address of the next instruction in sequence is saved. (2) The instruction at the P address is the next one executed. (3) The data in the field at the Q address is transmitted to the P address minus one and to successively lower core storage positions.

This instruction is used to branch to subroutines.

The Branch Back (BB-42) instruction causes the computer to branch unconditionally to the instruction at the address saved by the Branch and Transmit instruction. This instruction is used to return from a subroutine.

The Transmit Field (TF-26) instruction causes the data field at the Q address to be transmitted to the field at the P address.

The Transmit Record (TR-31) causes the data at the Q address to be transmitted to the P address and successively higher core storage positions until terminated by a record mark (Ref 6:21-27).

A Define Origin (DORG) statement instructs the processor to override its automatic assignment of storage and to begin the assignment of succeeding instructions at the location specified in the operand.

A Define Constant (DC) statement is used to enter numerical constants into the object program, and to assign names to the constants.

A Define Symbol (DS) statement is used to define symbols used in the source program by assigning storage addresses or values to symbolic addresses or labels. It also assigns storage for input, output, or working areas (Ref 5:17-20,37).

Processor Operation

The processor is the 1620 machine language program which performs the function of translation and assembly. The processor takes the source program in symbolic language, converts the mnemonic codes into machine language codes, assigns addresses in core storage to instructions and symbols, and assembles a machine language program known as the "object" program (Ref 18:2). The general operation of the processor in performing these functions is described below.

The processing of a source program is accomplished in two passes. A statement is read, and if the statement is not a comment the operation code field is identified by a search through the operation code table. Each entry of this table contains the mnemonic code and a code digit to indicate the routine which processes this class of instructions. When the correct op code has been identified a branch to the routine that will process that class of instructions is executed.

During pass I, after the statement has been processed by the appropriate routine and the address counter has been adjusted, a branch is made to the label loading routine. In this routine the label is first tested to see if it is blank, and if it is, a branch to process the next statement occurs. If the label is not blank a search is made of the symbol table. If the label is

already present, it is multiply defined, and the statement is treated as if it had a blank label. If the label is not already present, and space is available in the table, the label is placed in the table together with its assigned address.

During pass II the instruction operands are scanned and assembled by a closed subroutine which operates as follows: The operand field is scanned and the characters are collected and examined. If the characters represent a symbol, the symbol table is searched for equivalence, and if the symbol is not found, the symbol is undefined. If the symbol is present, its assigned address is stored and address adjustment, if designated, is performed. After all symbols in the field have been collected and evaluated, a branch back from the routine occurs, and the instruction is then assembled and readied for output (Ref 17:10-15).

III. General Procedure

The purpose of this chapter is to outline the chief steps of the thesis investigation. The chapter will describe the basic computer programming process and the associated equipment that was utilized in modifying the IBM 1620 SPS Processor Program. Photographs and descriptions of this equipment are included in Appendix A.

Analysis of the Processor Program

The first step in the programming process consists of analyzing a listing of the processor program to determine possible areas of modification. This listing can be obtained from the IBM Program Library or can be printed on the IBM 407 accounting machine from the SPS Processor Source deck. For this thesis project the program was analyzed in terms of the two major areas of investigation that were described in chapter I - to determine how the program could be shortened and its capability increased.

Modification of the Processor Program

After completion of the initial analysis the program changes must be converted to coded instructions and incorporated into the processor program. At this point the basic techniques of computer programming and coding which are described in detail in chapter IV are applied. Since many listings of the program will be made during

the course of the programming process, the number of modifications made on any particular listing is a matter of convenience.

Preparation of the Source Deck for a New Listing

The coded instructions that were prepared in step two must now be punched on IBM cards and inserted in the SPS source deck as modifications to the program. After all desired changes and deletions have been made the SPS source deck can be used to obtain a new listing. If further modifications are planned the listing is made on the IBM 407 and the foregoing procedure repeated until all changes have been incorporated.

Program Assembly

When all modifications have been incorporated into the processor source deck the program is assembled on the computer. Due to the number of symbols used in the modified processor program the IBM 1620 could not be used; consequently all assemblies were performed on the IBM 7090 Data Processing System. The input data consisted of the 7090 processor card deck and the modified SPS processor source deck. Since the input to the 7090 is from tape only, off-line card-to-tape conversions were performed on the IBM 1401 Data Processing System.

The output of the 7090 is a listing of the original input data and the assembled machine language instructions, written on another tape for off-line reproduction. Under

control of the IBM 1401, the IBM 1402 Card Read-Punch and the IBM 1403 Printer are used to convert this tape listing to an output object deck and a printed listing.

The complete assembly process using the IBM 7090 is accomplished by the Analysis Branch, ASNCDA.

7090 Listing

The output listing of the 7090 contains the source statements in SPS format and the machine language instructions and storage addresses of the processor program. Error messages, which are identified by five asterisks, are printed out and precede the statement in error. The symbol table and all undefined and multiply defined symbols are printed out at the end of the listing.

If there are an excessive number of errors in the listing the SPS source card deck should be modified and a new assembly made. If there are few errors, corrections can be made by inserting patch cards in the 7090 output object deck.

Program Checkout

The 7090 output object deck is now loaded into the IBM 1620 computer and standard computer techniques utilized to check out the new processor. The checkout procedures* are used in conjunction with the printed listing obtained

*The checkout procedures are described in detail in chapter V.

from the 7090 to trouble-shoot the processor program. As errors in the program are encountered, corrections are made to the listing by rewriting the necessary coded instructions. When a number of corrections have been accumulated, the modifications should be punched on cards, inserted in the SPS processor source deck and the entire programming process repeated to obtain a corrected object deck.

This process is continued until an operational processor program is obtained that incorporates all the desired modifications and changes.

Write Up

As the processor is being tested the operating procedures and techniques that best incorporate the modifications into a workable program are being formulated. When the optimum combination of convenience, flexibility and capability has been obtained, a list of operating instructions and a description of the modifications in the program are compiled into a reference manual for general distribution at the computer facility.

Program Library

In order to maintain the sequence of the coded statements the final processor program is renumbered using the 1620 Sequence Puncher Program. This program assembles a new source deck that contains the statement numbering

sequence designated by the operator. Since the 1620 output card deck is unprinted, the IBM 557 Alphabetic Interpreter must then be used to print the coded statements on the punched cards. The numbered and printed source deck is then used to obtain a final numbered listing from the 7090 for inclusion in the Program Library.

As an optional enclosure a Label Reference Index can be prepared using a 1620 program written by Lt. Pratt. This program assembles an object deck containing a list of all symbols and the card numbers of every location in the program which refers to each symbol. Due to the number of symbols used in the AFIT Version of 1620 SPS additional memory space was required and the School of Logistics 1620 computer facility, which has 40,000 spaces of core storage, was utilized to assemble the program. A printed listing of the Label Reference Index was prepared from the object deck using the IBM 407.

IV. Methodology

This chapter consists of two parts. The first section describes the concepts, methods, and coding techniques that were utilized to shorten the IBM SPS Processor Program. The second part outlines the computer programming and coding techniques that were utilized to increase the capability of the IBM SPS Processor.

Although these two areas of investigation will be described separately in this chapter, they are closely interrelated. The techniques employed in shortening the processor program are equally applicable to the problem of programming and coding computer routines to increase the capability of the processor. Moreover the recoding procedure, which is used extensively as a shortening technique, is also utilized directly to incorporate major changes into the processor without the necessity of adding complete new routines to the program.

Shortening the IBM SPS Processor

As outlined in chapter II, the function of the processor program is to translate the symbolic language used by the programmer in his source program into the operating machine language of the computer. Since the central limitation of the size of a source program is the number of symbols that the computer can accept, there exits a definite trade-off problem between the size of

the symbol table and the length of the processor program. The essential feature of this problem is that the processor program, which only performs the necessary translation procedures, occupies a substantial amount of memory storage space. The significance of the problem is illustrated in Figure 3 on the next page, which indicates that the processor program occupies approximately 17,500 of the 20,000 memory spaces available in the 1620 Data Processing System. If the processor program could be shortened by modification that would not alter the capability of the processor, additional storage space would be available in the symbol table for programming longer and more complicated problems. The remainder of this chapter will examine the programming techniques utilized to modify the processor program.

The programming techniques that were applied to the IBM SPS Processor Program were employed on the basis of the following criterion: "Given a fairly efficient program written in a straightforward manner, it is usually possible to rewrite the program in fewer instructions, but the rewritten program will require increased execution time." In general however, the percentage of decreased space will be considerably larger than the percentage of increased execution time (Ref 4:2).

Since the limitation of memory capacity for the source program symbol table is the most stringent restriction upon

the SPS programmer, the processor program was rewritten to optimize storage space and the penalty of increased execution time, when it occured, was accepted. In many cases, however, execution time was actually decreased due to better programming.

Program	Storage Addresses
Arithmetic Tables	00000 - 00401
Input/Output Areas, Work Storage, Constants	00402 - 01779
Processor Program Instructions	01780 - 15403
Input/Output Areas, Work Storage Constants	15404 - 15844
Operation Code Table (Mnemonics)	15845 - 17516
Symbol Table	17517 - 19999

Fig. 3

Storage Layout of 1620/1710 SPS Processor

Six different techniques were employed in shortening the processor program. These were: (1) Recoding, (2) Optimum use of all portions of an instruction, (3) Redefinition of origin to optimize storage, (4) Optimum use of programmed switches, (5) Looping, and (6) Subroutine formulation (Ref 11:2-6).

The application of these techniques comprised a substantial portion of the thesis investigation; therefore a detailed explanation of the techniques and an illustration of their application to the IBM SPS Processor will be presented in this chapter.

The subroutine and looping techniques accomplished the most significant results in shortening the processor program. The other methods, although less important, were useful coding techniques that were applied to the processor and to the routines formulated using the subroutine and looping methods. In order that the minor techniques will be recognized and appreciated when they appear in the subroutine and looping illustrative examples, they will be discussed first.

Recoding. This technique consists of altering instruction combinations that satisfy the logic of a particular program or routine. It was possible to conserve memory storage by altering the particular logic and/or utilizing different instructions in a different sequence to accomplish the same function.

This technique was applied to the routine in Figure 4 which used the last digit of the op-code field to branch to the correct routine to process an instruction. These routines accomplish the same function in both processors, but the AFIT Processor utilizes 64 fewer spaces in core storage.

IBM PROCESSOR

```
OK      TFM   GOODB+6,BTBL
        TD    GOODB+11,ZEP0+30
        A     GOODB+5,GOODB+11
GOODB   B     ,,10
        B     TRA
        DORG  *-1
        D     ADC
        DORG  *-1
        B     MACRO
        DORG  *-1
        B     INST
        DORG  *-1
        B     BI
        DORG  *-1
        B     BNI
        DORG  *-1
        B     RDW
        DORG  *-1
        B     K
        DORG  *-1
        B     DSDNB
        DORG  *-1
        B     DAS
        DORG  *-1
        B     DC
        DORG  *-1
        B     DAC
        DORG  *-1
        B     DSA
        DORG  *-1
        B     DSB
        DORG  *-1
        B     DORG
        DORG  *-1
        B     DEND
        DORG  *-1
        B     HEADER
        DORG  *-3
```

AFIT VERSION OF 1620 SPS

```
OK      TFM   GOOD1+11,BTBL
        TD    GOODB+11,ZEP0+30
GOODB   MM    *+9,500,810
        A     GOOD1+11,99
GOOD1   TF    GOOD2+6
GOOD2   B
        DORG  *-4
        DSA   MACRO
        DSA   TRA,INST,BI,BNI
        DSA   RDW,K
BTBL    DSA   DSDNB,DAS,DC,DAC,
              DSA
        DSA   DSB,DORG,DEND,
              HEADER,MORG
```

Fig. 4

Recoding

A second aspect of the recoding technique involves the elimination of the asterisk address adjustment feature from the majority of instructions in the processor. This improved the readability of the processor and made modification and coding simpler; however the number of symbols required was substantially increased. The following routine which handles the typed output for the DSA statements illustrates the application of this technique.

IBM SPS PROCESSOR

```
TYPDSA BNC1   PCON
       TFM    *+47,ZEPO
       WATY   CLERER+45
       AM     *+23,5
       TF     TYPADD-1
       WNTY   TYPADD-5
       TF     *+35,*-13
       AM     *+23,1,10
       BNR    *+20
       B      PCON
       DORG   *-3
```

AFIT VERSION OF THE SPS

```
TYPDSA BNF    PCON,PRSW
       TFM    B45+11,ZEPO
A22    WATY   CLERER+45
       AM     B45+11,5
B45    TF     TYPADD-1
       WNTY   TYPADD-5
       TF     B47+11,B45+11
       AM     B47+11,1,10
B47    BNR    B46
       B      PCON
       DORG   *-3
```

Optimum Use of all Portions of an Instruction. The use of declarative statements and address adjustment allows the assignment of constants and work areas within the unused portions of other instructions.

EXAMPLES: (X indicates an unused position)

SPS			UNOPTIMIZED MACHINE LANGUAGE INSTRUCTIONS
HI	TBTY		34 XXXXX X01X8
PICKUP	DS	5,*-5	
	.		
	.		
	.		
G30	H		48 XXXXX XXXXX
SEVENS	DC	7,7070707,*	
	.		
	.		
	.		A4
	BNC4	A4	47 $\overline{\text{AAAAA}}$ X04XX
CNTR	DS	2,*	
	.		

In the first example the symbol PICKUP is assigned a position within the unused portion of the instruction TBTY. The five digit area occupies the P address of the TBTY instruction.

In the second example the HALT instruction utilizes only 2 of the 12 machine language digits, consequently seven digits of the instruction are used for defining a constant labeled SEVENS. The resulting machine language instruction would be 48 000$\overline{7}$070707.

In the third example the symbol CNTR is assigned the location of the last two digits of the preceding instruction. A one-digit constant could be assigned the

Q_7 position of the instruction since this space is also unused.

Maximum use of this technique, particularly in the modifications that were added to the processor, eliminated unnecessary storage requirements.

Redefinition of Origin to Optimize Storage. This technique allows the unused portion of certain instructions to be eliminated in core storage. All instructions in the IBM 1620 are written in a 12-digit machine language format; however, in certain instructions the Q or P address is not used and a zero (00000) address is generated. A DORG statement (Define Origin) can be used to direct the processor to override its sequential assignment of storage and begin the assignment of succeeding instructions at the address specified in the operand of the DORG statement.

The DORG statement can be used to eliminate the unused portion of the Branch and Branch Back instructions.

```
B     START
DORG  *-3
.
.
.
BB
DORG  *-9
```

The "B" instruction uses only 7 of the 12 digits in the instruction format; consequently the redefinition of

the origin saves four positions of storage.

The BB instruction uses only 2 of the 12 digits; this allows a saving of ten positions.

Although these are the only two commands which allow this type of redefinition, and the IBM SPS Processor has been written utilizing this feature, this technique was applied successfully to all program modifications.

Optimum Use of Programmed Switches. The IBM SPS Processor used an indicator set to 0 or 1 to branch around those instructions that were not to be executed during pass I or II. The switch, which was 0 during the first pass, was set to 1 at the end of this pass to allow execution of the proper instructions for pass II. In the example that follows, during the second pass the Branch on Digit (BD) statement causes a branch around the instruction B LDLBL since at that time the program switch EJS has been set to 1.

EXAMPLE:

```
     BD   PRDS, EJS
     B    LDLBL
     DORG *-3
PRDS BTM  LINPRT, DODS
```

It was possible to optimize this programmed switch by using a record mark in place of the 1 and utilizing the Branch No Record Mark instruction:

```
          BNR LDLBL, EJS
PRDS BTM LINPRT, DODS
```

This modification saves eight spaces, and since this routine was used quite frequently in the processor, a considerable amount of storage space was saved.

Looping. Looping is the ability to repeat an operation. Loops within a computer program enable the computer to return to an earlier part of a program and repeat certain steps with different input data; this allows the computer to perform long repetitious tasks with relatively short simple sets of coded instructions and consequently provides a means to conserve memory storage space.

The open subroutine printed below provides an excellent example of looping. This routine was added to the processor program to clear the area labeled INPUT prior to reading a statement from an input device.

```
G15         TFM  SET,0,10
            TF   INPUT-2,CLERER+9
            TF   INPUT+10,CLERER+11
            TF   INPUT+18,CLERER+7
            TFM  AA2+6,INPUT+20
AA2         TFM  ,,10
            AM   AA2+6,2
            CM   AA2+6,INPUT+140
            BL   AA2
TYPE        DS   2,*
            BB
            DORG *-9
```

The BL (BRANCH LOW) instruction creates a loop back to the instruction labeled AA2 and allows the computer to repeat that sequence of operations immediately following AA2 as often as needed.

This particular technique proved extremely effective and was utilized extensively in modifying the IBM SPS Processor.

Formulation of Subroutines. A program which performs identical functions at various points within the program can be simplified by subroutining. Using this technique a function is coded only once and referenced freely, each reference affecting the program as though the function were coded completely at the place of reference.

A subroutine is a short sequence of coded instructions which performs a specific task. The subroutine is normally executed several times during the course of the main program and is incorporated into the program by a single coded instruction whenever the operation performed by the subroutine is desired. Since the subroutines are only coded once, memory space is conserved.

The processor program was analyzed to determine if additional subroutines could be formulated and considerable shortening was accomplished by the use of this method. In general, however, the original logic and coding had to be changed in order to create tasks that could be performed by identical procedures.

Figure 5 below is an example of two coded routines from the original processor that performed identical functions with different input data and a slightly different logic, and were designed to produce different results.

```
LBADD   TFM   *+23,SYMTBL          IT      TFM   *+23,SYMTBL
        BD    LBADDS                      BD    SEIFIN
        BTM   EVALER,50000                .
        DC    1,-,*                       .
LBADDS  TF    *+23,LBADD+23       SEIFIN  TF    *+23,IT+23
        TD    *+35                        TD    *+35
        TF    LABCOM+11,*-1               TF    *+71,*-1
        TFM   *+47,,10                    AM    *+59,,10
        A     *+35,*-1                    A     *+47,*-1
        A     LABCOM+11,*+23              C     LABCTR,SEIFIN+47
        CM    COLL-17                     BNE   *+36
        BNE   *+36                        C     INPUT3
LABCOM  C     COLL-2                      BE    ER10
        BE    LABOK                       TF    IT+23,*-13
        AM    LABCOM+11,6,10              AM    IT+23,6,10
        TF    LBADD+23,LABCOM+11          B     IT+12
        B     LBADD+12                    DORG  *-3
        DORG  *-3
```

Fig. 5
Routines Designed to Search the Symbol Table

These two routines were recoded into a single subroutine which resulted in reducing the length of the processor by approximately 100 spaces of core storage. The routine as it appears in the AFIT Version of 1620 SPS is printed on the next page.

```
IT      TFM   A63+11,SYMTBL
A63     BD    SEIFIN
D33     B
        DORG  *-3
SEIFIN  TF    D24+11,A63+11
D24     TD    D25+11
        TF    D26+11,D24+11
D25     AM    D26+11,,10
        A     D26+11,D25+11
D28     D     LABCTR,D25+11
        BNE   D27
D26     C     INPUT3
D29     BE    BB
D27     TF    A63+11,D26+11
        AM    A63+11,6,10
        B     A63
        DORG  *-3
```

The subroutine technique can be extended to provide an option to branch from a subroutine to any position of a program rather than to the next instruction in sequence.

In this technique a Branch and Transmit Immediate instruction is used to branch to the desired subroutine. The Q address of the BTM instruction contains the address to which the subroutine may branch upon completion.

Example: Assume that an instruction, BTM CKREC, NASS, which is located in another part of the program, causes a branch to the routine CKREC listed on the next page.

```
CKREC   TF      BR1+6,*-1
        BNR     BR2,INPUT+22
BR1     B
        DORG    *-3
BR2     CM      INPUT+22,23,10
        BE      BR1
        BB
        DORG    *-9
```

As a result of this branch, the Q address NASS will be stored in the CKREC-1 position.

The TF instruction of the subroutine will transmit the address NASS to the branch instruction BR1+6.

The subroutine will perform the designated checks and depending on the results proceed to Branch Back or to Branch to the routine located at NASS.

Several subroutines were formed in this manner and a considerable saving of storage space was realized.

A third type of subroutine, the multiple use subroutine, also proved quite effective. This type of subroutine permits a BTM instruction to branch to various instructions within the routine, to allow execution of only a portion of the subroutine.

An example of this type of subroutine is given on the next page.

Example:

```
TABBY1   TBTY
         TBTY
         TBTY
         TF     G25+6,TABBY1-1
G25      B
         DORG   *-3
G5       AM     ADDRS,5,10
SPAT     WNTY   ADDRS-4
         SPTY
         BB
         DORG   *-9
```

The following Branch and Transmit Immediate instructions were used to branch to this subroutine:

BTM TABBY1,G5 which allows the complete subroutine to be processed.

BTM TABBY1,*+12 which allows the three TBTY instructions to be executed and causes a branch to the instruction immediately following the BTM instruction.

BT SPAT, SPAT-1 which causes only the last portion of the subroutine to be processed.

A total of six subroutines were formed utilizing all of the techniques described in this chapter. This technique produced the greatest reduction in storage space.

Processor Capability

The second major area of investigation was to increase the capability of the SPS processor by incorporating the necessary coded routines or modifications into the

processor program. Suggestions were available from many sources, and ideas from my thesis advisor, reports from the various 1620 Users Group Meetings, and my own computer experience, were all used as a guide in modifying the program. In the final analysis all modifications were based on my own judgement, the only criterion being the desired result - a flexible, useful, processor program with an extended capability.

The problem of increasing the capability of the processor program was essentially the problem of writing a short computer program or routine to perform the function desired. This routine had to define in complete detail what the computer was to do under every conceivable combination of circumstances with all information fed into it.

The number of coded instructions required to perform a particular function varied according to the nature of the task. Since the computer executes instructions one after another, it was necessary to include in the program appropriate instructions to direct the computer to repeat, modify, or skip over certain instructions, depending on the intermediate results or circumstances.

The techniques described under part I of this chapter were equally applicable to the problem of writing computer routines. The subroutining and looping methods, combined with the other techniques of modifying instructions,

permitted a significant reduction in the number of instructions required to perform a specific function.

The general procedure utilized in preparing the routines was: (1) Establishment of the logical program segments to mechanize the operation to be performed, and (2) Arrangement of the coded instructions to satisfy the program logic.

It should be noted that this sequence of operations was repetitive in nature since the peculiarities of the machine logic often necessitated changes in the program logic.

Six new routines were added to the program that resulted in an increased capability for the processor. These routines provided a means to (1) find the size of memory, (2) perform an address check during pass II, (3) include an additional operation code in the program, (4) have the typewriter space over the seam in the paper while listing, (5) reduce the time required to type out a source statement, and (6) eliminate the necessity for a record mark at the end of a statement when utilizing typewriter input.

In addition the recoding procedure, which was used extensively as a shortening technique, was also utilized to increase the capability of the processor. Major changes were incorporated in many routines in the IBM Processor resulting in the addition of eight features to the processor program.

```
NAST    BNF     G26,PRSW
        TF      LOPOUT,INPUT-2
        C       LOPOUT,CLERER+9
        BNE     G16
        TBTY
G19     TF      LOPOUT,INPUT+10
        BD      G17,LOPOUT-11
        TBTY
ORDER   DC      4,1,*-4
        B       G18
        DORG    *-3
G16     WATY    LOPOUT-8
        B       G19
        DORG    *-3
G17     WATY    LOPOUT-10
G18     TF      LOPOUT,INPUT+18
        WATY    LOPOUT-6
        BNR     B8,INPUT+20
        B       A49
        DORG    *-3
```

Fig. 7
Routine to Type Out Source Statement

The routine in Figure 7 gives an example of several of the techniques described in part I of this chapter. This routine was included in the AFIT Version of the SPS Processor to allow the typewriter to tabulate (rather than space) to the proper position for type out of a statement if either the page-line field or the label field were blank. The function and logic of this routine is indicated in the flow diagram of Figure 6.

This routine is an excellent example of the trade-off problem of space, execution time and capability. The routine in the original processor accomplished the type out of the statement with fewer coded instructions, but the method of spacing rather than tabulating when blank fields were present was time consuming. To improve the performance of the SPS Processor additional instructions were added which decreased the computer execution time, and resulted in a faster listing due to the increased speed of the typewriter when tabulating. The increased storage requirement imposed by the additional instructions was a trade-off to obtain a reduction in the order of seconds of computer execution time.

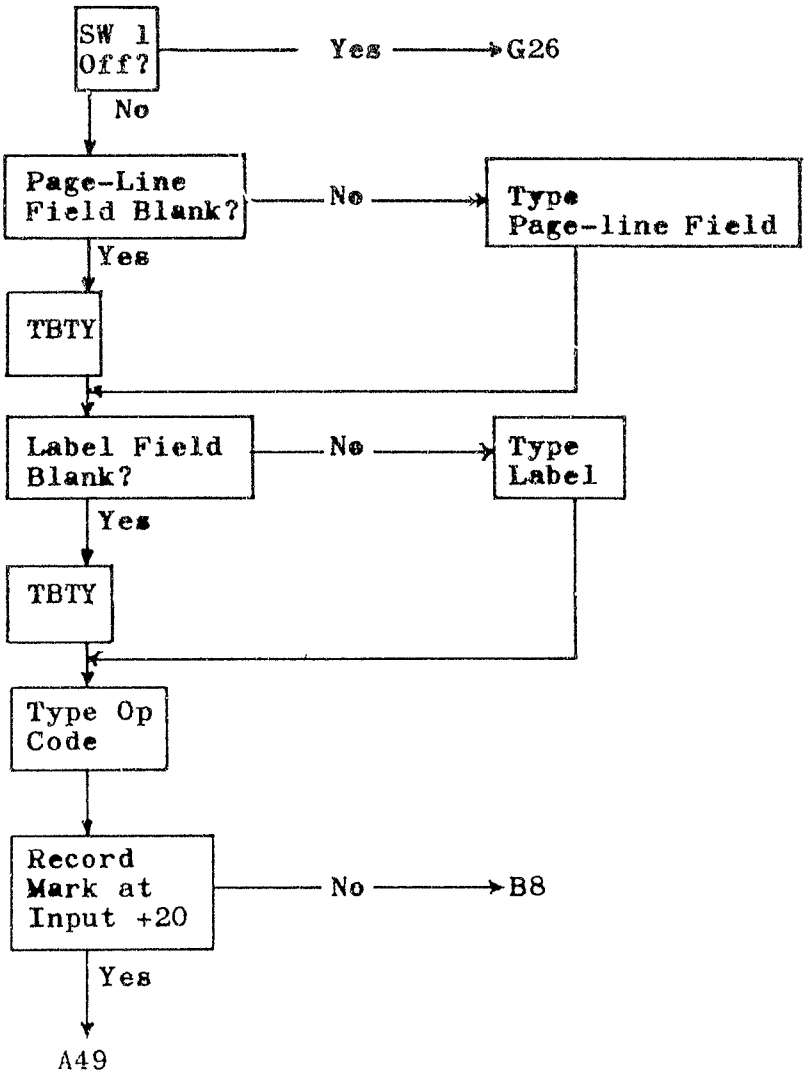

Fig. 6

Flow Diagram of the Routine: Type-Out Source Statement

V. Program Checkout

This chapter will discuss the sixth step of the programming process - checkout of the modified processor program. This step is a major area of investigation, constituting approximately one half of the total time expended on the programming effort, and requiring thorough knowledge of the operating procedures and techniques used to analyze programs in the computer.

An outline of computer operating instructions, equipment, capability, and program testing procedures is included in the IBM Reference Manual A26-4500-2, titled IBM 1620 Data Processing System. No attempt will be made in this chapter to write a definitive study or repetition of this manual; rather, a functional description of those features that proved most valuable to the thesis investigation will be presented. The remainder of this chapter, which is divided into three parts - test requirements, console operation, and debugging techniques - describes these features.

Test Requirements

Adequate checkout of the modified processor program depended on the test of the major individual routines that comprise the processor program. These individual routines were checked out by employing five phases of testing.

(1) Typical flow of the processor, (2) Check of specific routines that handled all instructions containing certain classes of op codes, (3) Error handling procedures, (4) Test of the specific changes and modifications to the processor program, and (5) Final recheck of the complete overall operation of the processor program.

The first phase of testing checked the typical flow of the processor by utilizing a short source program of known configuration to check the input/output routines of the processor. A typical configuration of this short source program is pictured in Figure 8 which shows a listing of the program obtained at the end of phase I.

```
END ØF PASS I
01012 *START1  01023    CNTR1
      * INITIALIZATIØN
            DØRG 1000                01000
            RCTY                     01000 34 00000 00102
      START1 TFM  CNTR1,0            01012 16 01023 ō0000
      CNTR1  DS   5,*                01023 00005
            DEND START1              01012
END ØF PASS II
```

Fig. 8
Test Program for Phase I

During Pass I checks were made to determine if (1) statements could be entered from the card reader and the typewriter, (2) error messages would be detected on correct source statements, (3) symbols would be entered into the

symbol table correctly.

During Pass II additional checks were made to determine if (4) the addresses in the statement operands would be evaluated correctly, (5) the type out of the source statements and the assembled instructions was correct, and (6) an uncondensed object deck could be punched.

Major errors were encountered during this phase of the testing and the debugging techniques described later in this chapter were employed extensively. Further checkout of the processor depended on establishing the correct I/O routines in order that all additional errors could be isolated to their respective routines.

Upon completion of phase I testing a check was performed on the specific routines that handled statements according to their class of op-code. The actual coding of the processor simplified this test materially, since only 17 routines process all 116 possible SPS operation codes. These 17 routines are listed in Figure 9 with their respective classes of instructions.

Routine	Instruction
MACRO	All macro-instructions
INST	All arithmetic and internal data transmission, some logic (Branch and Compare) instructions
BI	All Unique Branch Indicator ON MNEMONICS
BNI	All Unique Branch Indicator OFF MNEMONICS
RDW	Input/output instructions
K	Typewriter control instructions
DC	DSC and DC
DSDNB	DS,DSS,DNB
DAS,DAC,DSA,DSB,DORG DEND,HEADER,MORG,TRA	One routine for each instruction

Fig. 9
Processor Instruction Routines

All routines were tested by processing the appropriate instruction; where one routine handled multiple instructions one of each type was processed. For example: one arithmetic, one Transmit Field, one Branch, and one Compare instruction were used for testing the routine labeled INST; a DC and a DSC were used to test the DC routine. All statements were processed through the typical flow of the processor using phase I test criteria.

Figure 10 shows the listing obtained from a short program designed to test these instruction routines.

```
*  INITIALIZATIØN
          DØRG  1000                                  01000
 START1   TFM   CNTR1,                                01000 16 01248 ō0000
 CNTR1    DS    5, 1248                               01248 00005
          FA    START1,CNTR1                          01012 16 02031 ō1035
                                                      01024 49 02000 00000
                                                      01031 00005    ō0100
                                                      01038 00005    ō1248
          TRA                                         01042 36 00000 00500
                                                      01054 49 00000 00000
          AM    CNTR1,1                               01066 11 01248 ō0001
 ALPHA    B     START1                                01078 49 01000 00000
          C     ALPHA,START1                          01090 24 01078 01000
          BE    START1                                01102 46 01000 01200
          BNH   START1                                01114 47 01000 01100
          RATY  START1                                01126 37 01000 00100
          SPTY                                        01138 34 00000 00101
          RCTY                                        01150 34 00000 00102
 AREA3    DS    5,*-5                                 01156 00005
 BLANKS   DNB   6                                     01167 00006
 AREA1    DAS   80                                    01169 00080
 DELTA    DSS   7                                     01328 00007
 END      DC    1,                                    01335 00001
          DSC   25,                                   01336 00025
 NØTE1    DAC   19,NUMBER ØF RECØRDS @                01363 00019
          DSA   END,ALPHA                             01404 00005    ō1335
                                                      01416 00005    ō1078
          DSB   15,2                                  01424 00015 00002
          MØRG  2000                                  02000
          HEAD  X
          DEND  START1                                01000
LØAD SUBRØUTINES
```

Fig. 10

Instruction Routine Test Program

The third phase of testing involved checkout of the error handling procedures. Statements containing one of each of the 14 possible errors were processed through the phase I test procedure. Where one error message reflected multiple possible errors, each type of error was processed. The test was designed to check detection of the error, type-out of the proper error message, and proper assembly of the machine language instructions based on the error code. The listing of the program used for checkout of the error handling procedures is shown in Figure 11. Errors 9 and 13 were checked separately and are not included in the listing.

The fourth phase of testing was devoted to checkout of the specific modifications incorporated into the program to increase the capability of the processor. Checks were made to determine if they would actually perform the function they were programmed to perform. The specific routines that were checked are summarized in the next chapter under results.

As the routines were being tested the operating procedures that best incorporated the modifications into the processor program were also determined. These procedures became the operating instructions for the modified processor.

Since numerous modifications were added during each phase of testing, a complete recheck of the processor was required during Phase V. All previous test programs

```
      *  INITIALIZATION
               DØRG 1000                                  01000
      START1   TFM  CNTR1,                                01000 16 01248 00000
      CNTR1    DS   5, 1248                               01248 00005
      ENDS     TFM  START1,CNTR1,7                        ER 1
                                                          01012 41 00000 00000
      END@     TFM  START1,CNTR1,7                        ER 1
                                                          01024 41 00000 00000
      J        C    10000*10000*100,START1                ER 2
                                                          01036 24 00000 01000
      ENDS     TA   START1,CNTR1,7                        ER 3
                                                          01048 41 00000 00000
                                                          ER 10
      H        A    CNTR1,$1START1                        ER 5
                                                          01060 21 01248 00000
               TF   STARTED,SCAN                          ER 5
                                                          01072 26 00000 02285
      I        A    123456,START1                         ER 5
                                                          01084 21 00000 01000
      K        A    BØB,START1                            ER 5
                                                          01096 21 00000 01000
               TF   STØP(,SCAN                            ER 5
                                                          01108 26 00000 02285
               DSA  A,B,C,D,E,F,G,H,I,J,K                 ER 6
                                                          01124 00005    00002185
                                                          01136 00005    00002186
                                                          01148 00005    00001735
                                                          01160 00005    00001787
                                                          01172 00005    00001935
                                                          01184 00005    00001986
                                                          01196 00005    00002037
                                                          01208 00005    00001060
                                                          01220 00005    00001084
                                                          01232 00005    00001036
               DSB  15                                    ER 7
                                                          01684 00050
               DC   52,                                   ER 8
                                                          01734 00050
      C        DSC  52,                                   ER 8
                                                          01735 00050
      D        DAC  52,                                   ER 8
                                                          01787 00050
      E        DNB  52,                                   ER 8
                                                          01935 00050
      STØP     DC   5                                     ER 8
                                                          01985 00050
      F        DSC  2,                                    ER 8
                                                          01986 00050
      G        DAC  4,                                    ER 8
                                                          02037 00050
      A        DC   4,12345                               ER 8
                                                          02185 00050
      B        DSC  4,12345                               ER 8
                                                          02186 00050
      SCAN     DC   5,123456                              ER 8
                                                          02285 00050
               DAC  5,STØP                                ER 8
                                                          02287 00050
      START1   TF   STØP.SCAN                             02386 26 01985 02285
                                                          ER 10
               HEAD -                                     ER 12
      TIP$     B    START1                                02398 49 01000 00000ER 14
      TIP*     B    START1                                02410 49 01000 00000ER 14
      TIP-     B    START1                                02422 49 01000 00000ER 14
      TIP,     B    START1                                02434 49 01000 00000ER 14
      123      B    START1                                02446 49 01000 00000ER 14
               DEND START1                                01000
END ØF PASS II
```

Fig. 11

Error Handling Procedure Test Program

```
*  INITIALIZATION
          ORG  1000                                  01000
START1    TFM  CNTR1,0                               01000 16 01215 00000
          TFM  CNTR2,0                               01012 16 01263 00000
          TFM  A1+6,10000                            01024 16 01102 10000
          TFM  B1+11,10001                           01036 16 01119 10001
          TFM  A2+6,10001                            01048 16 01318 10001
          TFM  B2+11,10001                           01060 16 01359 10001
          BLC  *+12                                  01072 46 01084 00200
START2    RACD AREA1                                 01084 37 01589 00500
A1        TR   10000,AREA1-1                         01096 31 10000 01588
B1        BNR  AREA2,10001                           01108 45 01504 10001
          AM   CNTR1,1                               01120 11 01215 00001
          AM   A1+6,2                                01132 11 01102 00002
          TF   AREA3,B1+11                           01144 26 01198 01119
          AM   B1+11,2                               01156 11 01119 00002
          BNLC START2                                01168 47 01084 00200
          TF   AREA4,CNTR1                           01180 26 01246 01215
          RCTY                                       01192 34 00000 00102
AREA3     DS   5,*-5                                 01198 00005
          DC   1,0,*-4                               01199 00001
          CF   AREA4-4                               01204 33 01242 00000
CNTR1     DS   5,*                                   01215 00005
          WATY NOTE1                                 01216 39 01749 00100
          WNTY AREA4-4                               01228 38 01242 00100
          RCTY                                       01240 34 00000 00102
AREA4     DS   5,*-5                                 01246 00005
          DC   1,0,*-4                               01247 00001
          CF   AREA3-4                               01252 33 01194 00000
CNTR2     DS   5,*                                   01263 00005
          WATY NOTE2                                 01264 39 01787 00100
          WNTY AREA3-4                               01276 38 01194 00100
          SM   B1+11,2                               01288 12 01119 00002
          RCTY                                       01300 34 00000 00102
A2        WATY 10001                                 01312 39 10001 00100
          RCTY                                       01324 34 00000 00102
          RCTY                                       01336 34 00000 00102
B2        BNR  AREA5,10001                           01348 45 01540 10001
          C    B1+11,B2+11                           01360 24 01119 01359
          BE   END                                   01372 46 01564 01200
          AM   B2+11,2                               01384 11 01359 00002
          TF   A2+6,B2+11                            01396 26 01318 01359
          AM   CNTR2,1                               01408 11 01263 00001
          TFM  CNTR1,0                               01420 16 01215 00000
A3        C    CNTR2,CNTR1                           01432 24 01263 01215
          BNH  A2                                    01444 47 01312 01100
          SPTY                                       01456 34 00000 00101
          SPTY                                       01468 34 00000 00101
          AM   CNTR1,1                               01480 11 01215 00001
          B    A3                                    01492 49 01432 00000
AREA2     AM   B1+11,2                               01504 11 01119 00002
          AM   A1+6,2                                01516 11 01102 00002
          B    B1                                    01528 49 01108 00000
AREA5     AM   B2+11,2                               01540 11 01359 00002
          B    B2                                    01552 49 01348 00000
END       H                                          01564 48 00000 00000
          B    START1                                01576 49 01000 00000
AREA1     DAS  80                                    01589 00080
NOTE1     DAC  19,NUMBER OF RECORDS =                01749 00019
NOTE2     DAC  30,ADDRESS OF FINAL RECORD MARK       01787 00030
          DEND START1                                01000
END OF PASS II
```

Fig. 11a

Phase V Overall Operation Test Program

were rerun and an additional program to test the overall operation of the processor was assembled. A condensed and uncondensed object program were punched and the condensed object deck was used to process data. Figure 11a is a listing of this program.

Console Operation

The operator's console, which is an integral part of the central processing unit, provides for manual and automatic monitoring and control of the system. For monitoring, the console provides small neon light indicators that display the contents of core storage, internal registers, and the machine and program status. The most important of these indicators are described below.

The Operation (OP) Register indicator consists of two lines of five lights each which display the bit configuration of the operation code in the last instruction executed.

The Memory Address Register (MAR) is a bank of five lines of five indicator lights each which can display the bit configuration of the address in any one of the eight MARS registers. The MARS registers are non-addressable intermediate storage positions that control data flow and the addressing of core storage, and through the MAR display bank provide a visual indication of the internal data flow

of the computer. The operation code of an instruction determines the functions to be performed by the registers and designates the particular register to be used. The most frequently displayed registers are: (1) Instruction Address Register 1 (IR-1) - contains the address of the next instruction to be executed, (2) Product Address Register 1 (PR-1) - saves the address of the next instruction in sequence when the Save Key is operated, (3) Instruction Address Register 2 (IR-2) - saves the return address when BT and BTM instructions are executed, (4) Operand Address Register 1 (OR-1) - contains the Q address of the instruction indicated in the OP register after the I - cycle of the instruction, and (5) Operand Address Register 2 (OR-2) - contains the P address of the instruction in the OP register after the I - cycle of the instruction (Ref 6:60,71).

The MARS Display Selector is an eight position rotary switch that permits selection of any of the eight MARS registers for display in MAR.

The High/Positive (H/P) and the Equal/Zero (E/Z) check lights show the condition of their respective internal control gates as a result of the last arithmetic or compare operation.

Control keys are provided for alteration of certain machine functions and for convenient instruction entry. Signal lights are associated with some of the control keys

to indicate which key was last activated.

The Display Mar Key causes the MARS register to which the MARS Display Selector is set to be displayed in the MAR bank of indicating lights.

The Insert Key places the 1620 in automatic mode and activates the typewriter keyboard. This permits numeric instructions to be entered into core storage starting at 00000 and extending to higher numbered positions. The Release Key terminates the typewriter input operation and returns the 1620 to the manual mode.

The Stop/SIE Key stops the computer in the manual mode at the completion of the instruction being executed. Thereafter each depression of the key will cause a single instruction to be executed.

The Instant Stop/SCE Key causes the machine to stop while executing an instruction at the end of the 20-microsecond machine cycle in progress. Further depression of the key will cause the machine to step through single machine cycles.

The Save Key saves the address of the next instruction in sequence by storing the address in PR-1 (Ref 6:51-58).

Since the proper use of these indicators and control keys depends on the mode of operation of the computer a general understanding of this feature of the 1620 is required. The most important points are summarized below:

The 1620 computer can operate in either the automatic

or manual mode. In the manual mode the computer has terminated all operation and is ready to accept operator instructions. When the manual mode is initiated the Manual Light comes on and the program stops running. This occurs after: (1) a Halt instruction, (2) a Stop Key or SIE operation, (3) a Check Stop, (4) an Instant Stop or a SCE operation (automatic light is also on), and (5) depression of the Release Key to end a Read Typewriter instruction or Insert operation.

The manual light is turned off when the Start Key or Insert Key is depressed.

When a program is running the computer is in automatic mode and the automatic light is on. This condition exists during the following conditions: (1) when the Start Key or Insert Key is depressed, (2) when a Read Typewriter instruction is being executed, (3) when single cycling or if the program was stopped in the middle of an instruction by the Instant Stop Key, and (4) when running normally. While the computer is in the automatic mode the Display MAR, Save, Insert or Start operations cannot be executed (Ref 12:16-17).

When the computer is running, the lights on the control panel flicker. If the lights are not flickering the computer is stopped and one of several possible conditions could exist. If the computer stops running without displaying an error indicator, these conditions

would normally be (1) a programmed Halt, indicated by a 48 in the operation register, (2) the program waiting for information to be entered, indicated by a 36 or 37 in the operation register, (3) an illegal input/output device specified. This is indicated by a 38 or 39 in the operation register in combination with digits other than 01 or 05 in the Sense and Branch display indicator, or (4) a record mark at an address specified for output data. If the operation register contains an output code, a record mark (bit configuration C-8-2) displayed in the Memory Data Register would indicate an output instruction (WN for instance) had addressed a record mark. As another possibility, the computer should be checked to see if it is in automatic mode, since the system may actually be running in a very short loop. A programming error that failed to provide the proper conditional branch could cause the machine to hang up in a loop indefinitely (Ref 12:11,15).

Indicator check lights are provided on the console for monitoring the internal and input/output data flow of the computer. These indicators are used to detect parity errors within the computer and can stop computer operation. A description follows:

When the computer stops because of a parity check the Check Stop Light comes on. This condition is caused by (1) Read Check (RD CHK) or Write Check (WR CHK) Light coming on when the I/O switch is set to Stop, (2) Memory Buffer

Register-Even (MBR-E) or Memory Buffer Register-Odd Check Light coming on when the Parity switch is set to Stop, and/or (3) Memory Address Register Storage (MARS) Check Light coming on; this causes an unconditional machine stop regardless of the Parity switch setting. When the Check Stop light is on one or more of these indicators that actually caused the stop is also on. Two other means of stopping computer operation are (4) the Overflow Arithmetic (ARITH CHK) Check light when the Overflow switch is set to Stop, and (5) the Reader No Feed or Punch No Feed Light (Ref 6:51-57). The use of some of these indicators is explained below (Ref 6:51-57).

If the WR CHK light and either the MBR-E or MBR-O light are on, memory has a bad character. If the RD CHK light and either the MBR-E or MBR-O light are on a bad character has been read into memory. When the MARS check light is on, either a digit in MARS has a parity error or there is an illegal 5-digit address present in the register. A MARS check will also occur if two Branch Back instructions occur without a Branch and Transmit instruction intervening.

Debugging Techniques

As indicated in chapter III, program checkout commences when the modified processor object deck, which was assembled on the 7090, is loaded into the IBM 1620 computer. From this point the computer console is used in conjunction

with the printed listing from the 7090 to checkout the program in the computer.

The general checkout technique employed in this investigation utilized standard 1620 operating procedures in conjunction with the light indicators and control keys located on the computer console.

The initial checkout procedure was to allow the modified processor to process a short source program of known configuration, the essential idea being to check the typical flow of the processor program.

Operating errors in the modified processor program were determined by allowing the processor to process the source test program until a Check Stop forced a machine halt or until an incorrect output was obtained. Using this technique the majority of program errors encountered were found to be attributable to two primary problems. First, Transmit Field (TF) and Transmit Record (TR) instructions, because of a canceled flag or record mark in core storage, often erased a portion of the processor program at another location. Second, modification of the processor program for one purpose often had hidden higher order effects on some other process or routine in the program. The remainder of this chapter will discuss the debugging techniques used to analyze the major ramifications of these two problems.

The first of these problems resulted in the frequent

occurrence of the Check Stop and consequently led to the development of a general trouble-shooting procedure to deal with program errors of this nature. Since this procedure is a general trouble-shooting method and applicable to most SPS programs, the procedure is described in detail below so that it may serve as a reference for the inexperienced trouble shooter. It is essentially a compilation of standard console operating procedures that have been modified to meet the requirements of this investigation. The procedure is written from an operational point of view so that the technique of applying the standard console procedures as trouble-shooting aids can be fully appreciated.

Check Stop. When the Check Stop Light comes on the other indicator check lights should be examined to determine the type of check stop that occurred. Depending on switch settings the RD CHK, WR CHK, MBR-E and MBR-O lights should be scanned, and since the check stop is frequently a MARS CHK, the MAR display bank should be observed for content.

Scan the Operation Register. The operation register should be scanned to determine the op code of the last instruction executed. If the op code is invalid the immediate cause of the check stop is known, but the cause of the invalid op code remains to be determined. As indicated earlier the most frequent cause of an invalid

op code was due to a TR or TF instruction that caused data to cancel or replace the original instructions.

Determine Storage Address. The storage address of the last instruction should be determined next. This can be done by setting the MARS Display Selector to IR-1 and pressing RESET and Display MAR. Before pressing RESET the other indicators such as H/P and E/Z should be examined since they will be turned off by the RESET key. Now observe the address appearing in the MAR bank of indicator lights and subtract 12 from this number. The result is the address of the last instruction executed.

Determine Stored Data. The actual data located at the address just computed should be printed out on the typewriter for comparison with the listing. The procedure for printing storage data on the typewriter is as follows: (1) Press Insert, (2) Type 35 XXXXX 00100 where XXXXX is the storage address just determined. This causes data starting at XXXXX to be written numerically on the typewriter until location 19999 is printed or the release key is depressed. Occasionally it is desirable to start the type out at an address preceding the desired information to determine the extent of any erroneous field that may be present, and (3) Depress Release and Stop to execute step (2) (Ref 6:59).

Compare Actual Data and Listing. The data that was printed out on the typewriter should be compared with the

machine language instructions on the listing. If the fields are not identical, the SPS statements on the listing should be analyzed to determine which instruction may have caused the erroneous field to be present at this particular location. If this can not be determined from the listing trouble-shooting will have to continue as described below.

Isolating the Error. The simplest way to isolate the instruction causing the transfer of the incorrect data is to insert a digit with bad parity into the location receiving the incorrect data. When a TF or TR instruction attempts to transfer data into this location and the Parity switch is in the Stop position, the bad character will cause a check stop.

The basic procedure is as follows: (1) When the Check Stop occurs display IR-1 and determine the address of the instruction last executed, (2) Press Insert and enter a bad character (H) into an even numbered storage position located in the instruction just determined, and (3) Reprocess the last statement; when the Check Stop occurs, the address of the TF or TR instruction causing the transfer of incorrect data can be obtained by displaying IR-1 and determining the address of the last instruction executed.

A slower, more time consuming method for isolating an error is simply to process the statement through a

portion of the program before examining the location being altered. In this manner the approximate location of the instruction that is causing the transfer of incorrect data can be isolated.

A useful technique is to use the typewriter Program Alteration and Data Entry procedure to insert a Halt (48) instruction at selected positions in the processor program. Statements can now be processed normally; when the computer stops because of the Halt instruction, the statement can continue to be processed, one instruction at a time, by use of the Stop/SIE Key. The area being altered can now be periodically examined by the following procedure which accomplishes a type out of the stored data and a branch to the next sequential instruction: (1) Depress Stop/SIE, Save, Insert. The address of the next instruction in sequence is saved in PR-1 by depressing the Save Key. (2) Type 35 XXXXX 00100 42. (3) Depress Release and Start. Step 2 is executed and the data in core storage starting at XXXXX is typed out. (4) Depress Release and Start. The type out is halted, a Branch Back (42) to the address saved in PR-1 is executed and processing resumes (Ref 6:59).

Error Correction. When the statement causing the error has been isolated the erroneous data in core storage will have to be corrected. If much of the processor program has been canceled, the processor should be re-loaded into core storage. A few instructions can best be

entered from the typewriter using the Program Alteration and Data Entry procedure: (1) Press Insert. (2) Type: 36 XXXXX00100, (3) Depress Release and Start. The computer executes step 2 which instructs the computer to read numerically data entered from the typewriter into a location starting at XXXXX. (4) Type the correct data and press Release (Ref 6:58). All error corrections should eventually be entered on patch cards if the processor is to be reloaded at a later date. Major modifications will probably require correction of the SPS source deck and another assembly of the processor object deck on the 7090.

Reprocess the Last Statement. The statement which caused the Check Stop light to come on should now be reprocessed. The simplest procedure is to return to the location in the program where the Check Stop occurred. This can be done by pressing Insert, typing 49 YYYYY, where YYYYY stands for the storage address of the last instruction executed, and then depressing Release and Start. If major corrections were made in the processor, however, the test program may have to be completely rerun.

Miscellaneous Techniques. Several debugging techniques that are quite useful, but were not systematically employed in the general trouble-shooting procedure are described below.

The P and Q addresses of an instruction can be

displayed on the MAR indicator bank by: (1) Depressing Stop/SIE key until the instruction that contains the desired address is next. (2) Depressing the Instant Stop/SCE key eight times and then Reset once. (3) Turning the MARS Display Selector to OR-1 and depressing the Display MAR key. The Q address which is in OR-1 is displayed in the MAR bank. (4) Turning the MARS Display Selector to OR-2 and depressing the Display MAR key. The P address which is in OR-2 is displayed in the MAR bank (Ref 6:59). In most cases it was simpler to print the core storage data out on the typewriter using methods previously described.

A technique for determining a branch from a loop routine was helpful in isolating errors in the processor program. The result of compare and arithmetic instructions can be determined by observing the H/P or E/Z indicator lights. If the Stop/SIE key is being used to process a statement one instruction at a time, execution of a conditional branch after the compare or arithmetic instruction can then be anticipated to determine the completion of the loop routine. For example, a Branch Equal instruction after a compare instruction would be executed if the E/Z indicator light came on during the compare instruction.

Another useful technique is the procedure to determine whether a program has branched to a subroutine. Since the IR-2 register is normally blank and is used for the "BB" address, if this register contains a valid address,

the program is probably somewhere between a BT and BB (Ref 12:15). As illustrated in chapter IV, however, some subroutines function without using a BB. In that case, even though the program was not in the subroutine, IR-2 would still contain an address. Consequently IR-1 should be displayed first and if this address proves to be in a subroutine, IR-2 would then tell where the subroutine was entered from.

Let us now examine the second major checkout problem which concerns the higher order effect of modifications. The effects of this problem were primarily reflected in incorrect outputs that were many times removed from a specific modification. The general trouble-shooting procedure just described was extensively employed, but modified for the specific errors being investigated. Many minor errors were encountered, but the modifications that had the most far reaching effects are described below.

Modifications that incorporated the ability to enter a symbol during the second pass presented major trouble-shooting problems. By a series of related instructions, the original modification resulted in an incorrect output for all macro instructions. A detailed step by step analysis of this routine revealed that the operation of a single instruction transferred the wrong information into the area that was to be typed out for the listing of the assembled macro instruction. Further analysis

indicated that an output work area, that had originally been performing a different function for each pass, was now being forced to accept data for both functions during the second pass. A redefinition of the work area corrected this particular problem.

Major trouble-shooting problems also arose due to the alteration of the routines to search the symbol table for equivalence. Incorrect error messages were typed due to the alteration of program logic within the routines that branched to the subroutine searching the symbol table. After extensive trouble-shooting the program logic was modified and the errors were eliminated.

A third major problem arose due to the alteration of the routine that effected a branch to the proper routine for processing each class of instruction. The immediate noticeable effect was the incorrect type out of the assembled instruction during a listing. Investigation revealed that a change of the individual entries in the op code table was required in order to provide op code fields compatible with the modifications in the routine.

VI. Results, Conclusions and Recommendations

The improved IBM 1620 SPS Processor with its reduced memory storage requirements and its increased capability as outlined in this chapter has been designated the AFIT Version of 1620 SPS.

This chapter is a summary of the features and changes that have been incorporated into the AFIT Version of the 1620 SPS Processor. These modifications are the result of the application of the techniques described in chapters III, IV, and V to the IBM 1620 SPS Processor Program. A complete detailed description and operating instructions for the AFIT Version of 1620 SPS are included in the appendix.

Results

Two new macro instructions that were written by Lt. Pratt and added to the IBM 1620 SPS Processor now in use at the Institute of Technology have been incorporated in the AFIT Version of 1620 SPS. These instructions are designated (1) INC - Input Conversion, (2) OUTC - Output Conversion and provide for the conversion of floating point numbers from the internal form to the external form, and vice versa.

The following features which have been incorporated into the AFIT Version of the SPS Processor were outlined

and partially coded by Lt. Pratt. Analysis, modification, and complete checkout of the procedures were performed by the author to consolidate the program and to secure compatible operation of the indicated routines with the AFIT Version of 1620 SPS:

1. A new pseudo-op designated MORG, which allows the programmer to exercise more control over the addresses assigned by the processor, was added to the program.

2. A record mark is not required at the end of a statement when utilizing typewriter input.

3. After 60 lines of typing, a skip over the break in forms will be accomplished by the execution of six carriage returns.

4. The AFIT Version of 1620 SPS will automatically adjust itself to the size of memory; therefore, no modification of the processor card deck is required when additional storage is provided by the IBM 1623 Core Storage Unit.

5. The IBM 870 Document Writing System can be used to make an SPS listing from an SPS object deck. The format is similar to the typewriter listing on the 1620 console. Although this feature had been incorporated into the SPS processor now in use at the Institute of Technology, the procedure was modified and recoded and the ability to preserve the page-line field was incorporated.

6. The error message "adjustment count" has been renumbered to start at one instead of zero if an error occurs before a label has been defined.

The following features are the routines and procedures that were analyzed, coded and checked out by the author for incorporation into the AFIT Version of the 1620 SPS Processor Program:

7. An additional error check has been added and the error 10 message has been redefined to account for this check.

8. An undefined symbolic address, as a result of misspelling or omission, can be defined during pass II and placed in the symbol table. Detailed error correction procedures have been included in the writeup of this feature.

9. The effects of errors on the assembly process with program switch 2 OFF have been altered for error messages 1,3,5 and 11.

10. The symbol table is printed at the end of pass I rather than pass II.

11. With switch 1 ON for a listing on the console typewriter during pass II, if either the page-line field and/or the label field are blank, the typewriter will tabulate rather than space to the proper position for type out of the statement. In addition a space is inserted between the page-line field and the label field during

type out of the listing.

12. When a source deck is being punched during pass I and statements are being entered from the console typewriter, if switch 1 is turned ON to complete entry of the source statements from the card reader, the last entry from the typewriter will be punched in the source deck being prepared.

13. The procedure for the use of switch 4 to punch an object program has been altered.

14. If the processor is halted during either pass for any reason, it is possible to branch to the beginning of pass I by pressing RESET, INSERT, RELEASE, and START.

15. Complete operating procedures and instructions have been included in the writeup of the AFIT Processor.

Conclusions

The AFIT Version of the 1620 SPS Processor Program is a significant improvement of the IBM 1620 SPS Processor. Fifteen additional features have been added and the operating procedures have been altered to provide increased flexibility and convenience. The Processor has been shortened 699 spaces resulting in an extension of the symbol table from 2482 to 3181 memory storage spaces. This constitutes a 28 per cent increase in the size of the symbol table. Complete checkout of the program has been accomplished and detailed operating instructions have been prepared that should allow

this program to be utilized at the Institute of Technology's 1620 computer facility at an early date.

Recommendations

The AFIT Version of the 1620 SPS Processor Program is not compatible with the IBM 1620 subroutine deck. Although it is estimated that only minor modifications are required in the subroutine deck, completion of this work would greatly enhance the value of the AFIT Processor.

The computer facility at the Institute of Technology has recently been modified for several special features including indirect addressing. It may be possible to recode the SPS processor utilizing the indirect addressing feature to save considerable memory storage space and time. This possibility should be investigated and accomplished if feasible.

The final checkout of the processor revealed the presence of three undesirable features. These features can be eliminated by several minor modifications to the processor program. These are discussed below.

Unnecessary typewriter carriage returns and tabulations occur during pass II with switch 1 off in the type out of error messages 6, 7, and 8. The neatness of the listing is not affected by this typewriter operation and the addition of two instructions to the program will eliminate this feature.

During a listing on the console typewriter the storage

addresses of the symbols defined in a DSA (Define Symbolic Address) statement are not consistent with the designated length of the symbols. It is believed that a coding error in the output routine for this class of instructions is responsible for this inconsistency.

In the Load Label routine during pass II, if an ER10 address check is not indicated the label is again loaded into the symbol table. Since the symbol would have already been entered during pass I, this is an unnecessary duplication and computer execution time can be saved by recoding the routine. This modification can be incorporated by altering card number 26585 in order to cause a Branch Equal to D34 rather than G11.

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Appendix A

Facilities and Equipment

Appendix A contains photographs and descriptions of the facilities and equipment that were used in the course of this thesis investigation. Extensive use was made of the 1620 computer facility at the Institute of Technology, and the 7090 computer facility of the Analysis Branch, ASNCDA.

Fig. 13
1620 Data Processing System

The IBM 1620 Data Processing System is a small scientific computer designed for universities and small engineering consultant firms. The AFIT facility houses two units - the IBM 1620 Central Processing unit (which contains the computer, 20,000 positions of core storage, and an I/O typewriter) and the IBM 1622 Card Read-Punch unit which is available for card I/O operations.

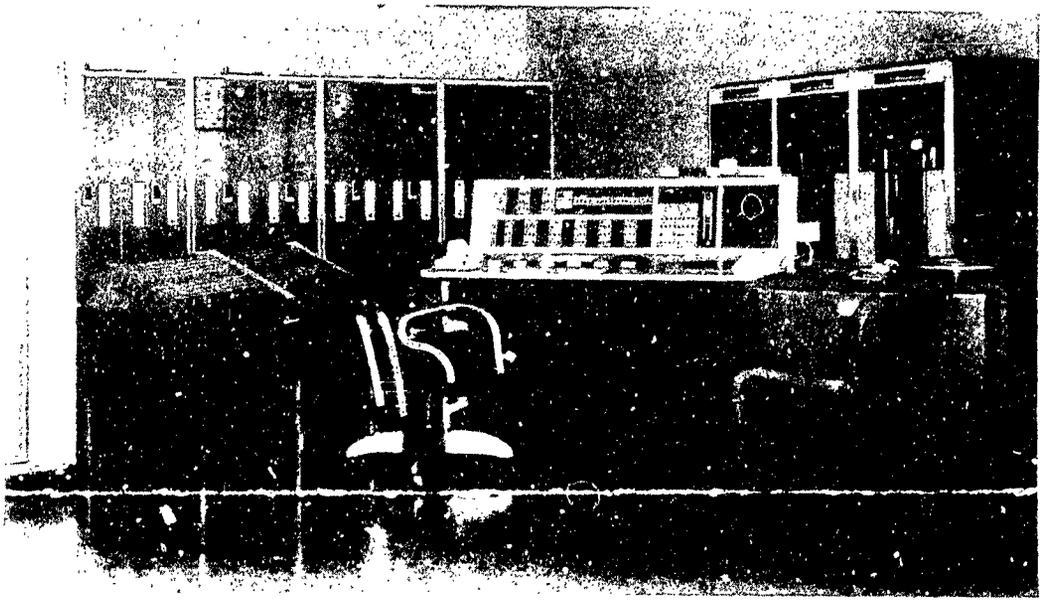

Fig. 14
The IBM 7090 Data Processing System

The IBM 7090 Data Processing System is a large scale high speed scientific data processing system. Input is from tape prepared in an off line card-to-tape prepared operation on the IBM 1401. The 7090 was used to assemble the modified processor program. The output was the SPS source statements and the assembled instructions written on tape to be listed off-line on the IBM 1401.

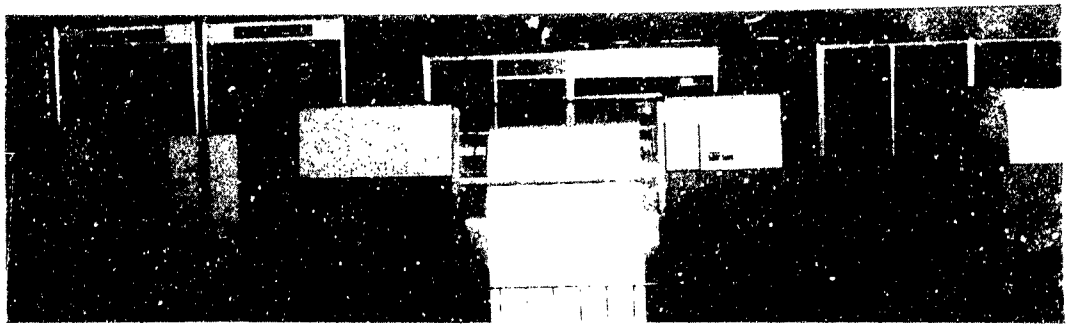

Fig. 15
The IBM 1401 Data Processing System

The IBM 1401 Data Processing System is used as an auxillary system for the IBM 7090 Data Processing System. This unit receives the tape output of the IBM 7090 and in an off-line operation controls the IBM 1403 Printer and the IBM 1402 Card Read-Punch output media which have respective rated outputs of 600 lines and 250 cards per minute. The 1401 is used to obtain a printed listing of the SPS source statements and their assembled machine language instructions, and a processor object card deck.

Fig. 16

The IBM 870 Document Writing System

The IBM 870 Document Writing System is a data transfer device. The AFIT facility houses the 836 Control Unit for use as a card punch, and one 866 Non-Transmitting Typewriter for use as an output listing station.

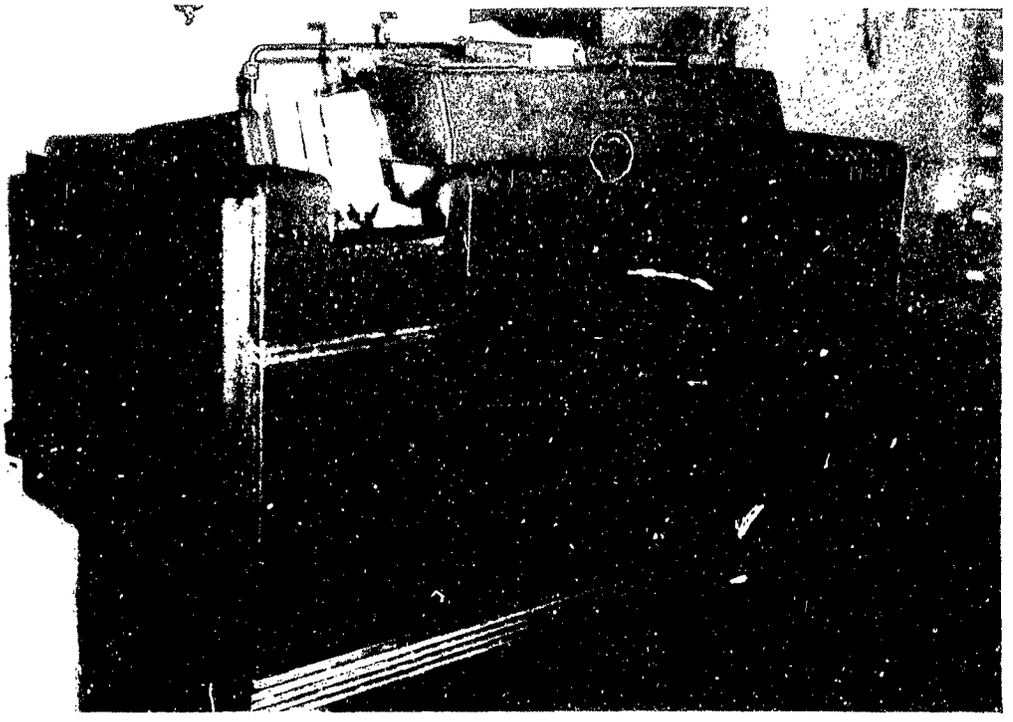

Fig. 17
The IBM 407 Accounting Machine

The IBM 407 Accounting Machine prepares printed listings from IBM cards. The 407 prints 18,000 characters a minute and reads IBM cards at the rate of 150 per minute. This unit is used to obtain a listing of the processor program in standard SPS format.

Appendix B

AFIT VERSION OF 1620 SPS

Contents

AFIT VERSION OF 1620 SPS

I. Introduction

This writeup is intended to serve as a reference text for the AFIT Version of the IBM 1620 Symbolic Programming System. It is assumed that the reader is familiar with the data handling methods and the functions of instructions in the 1620 Data Processing System. This information is available in the IBM Reference Manuals, 1620 Data Processing System, form A26-4500-2, and the IBM 1620/1710 Symbolic Programming System, form C26-500.

II. Description of the Program

The AFIT Version of 1620 SPS is an improvement of the IBM 1620 Symbolic Programming System. A detailed description of the specific modifications is included in the body supplement; for convenience the principal improvements are summarized below.

1. The size of the symbol table has been increased from 2482 to 3181 spaces of core storage. This constitutes a 28 per cent increase in the size of the symbol table.

2. An SPS object deck can now be listed on the IBM 870 in a format similar to the typewriter output listing of the 1620 console.

3. Symbolic labels on all statements can be defined and placed in the symbol table during pass II as well as Pass I.

4. The effects of errors on the assembly process with program switch 2 off have been altered for error messages 1,3,5, and 11.

5. Two new macro instructions designated (1) INC- Input Conversion, and (2) OUTC - Output Conversion have been added to provide for conversion of floating point numbers from both the internal form to the external form and the reverse.

6. A new pseudo-op designated MORG, which allows the programmer to exercise more control over the addresses assigned by the processor, has been added to the program.

7. Typewriter input, output, and correction procedures have been altered to provide increased convenience and flexibility.

8. All operation codes that were exclusively for use with the 1710 or for paper tape input/output have been eliminated from the program. Most non-unique input/output instructions have also been omitted.

III. Program Configuration

This program has been written for the IBM 1620 Data Processing System with 20,000 digits of core storage and for use exclusively with the 1622 card reader punch. The program automatically adjusts to the size of core storage and is compatible with the 1623 Core Storage Unit.

This program utilizes no special features but is

compatible with a computer which has these special features.

The program as of this writing is not compatible with the IBM 1620 subroutine deck. It is anticipated, however, that only minor modifications in the subroutine deck will eliminate this discrepancy.

IV. Operation of the Processor

The AFIT Version of the 1620 SPS card processor is a two pass program. The input for both passes is provided by a source program written in the symbolic language of the SPS.

The two major changes to the basic functions of the IBM SPS processor during pass I and II are: (1) The symbol table will be printed at the end of pass I rather than pass II, and (2) Symbolic labels can now be placed in the symbol table during pass II. The functions of pass I and II are described below.

During pass I the processor (1) checks mnemonic operation codes for validity, (2) prepares a table of symbolic labels and their assigned addresses for use during the second pass, (3) assigns storage positions in memory to constants, instructions, and work areas, (4) performs error checks on the source statements and produces error messages, and (5) prints the symbol table, if desired (Ref 5:79).

During pass II the processor (1) processes the operation codes by converting the mnemonic codes to their 1620 machine language equivalents, (2) Processes statement operands according to the type of operation code. Looks up assigned storage addresses and their symbolic operands in the symbol table that was prepared during pass I. Performs address adjustment, when required, to complete the operands. Examines the flag indicator operand and sets flags in the assembled instruction, (3) processes corrected or newly defined symbolic labels and places them in the symbol table, (4) types error messages for those statements that are unable to be assembled properly, and (5) prepares the assembled output (Ref 5:79).

The operation of the processor is described below:

Pass I input for the processor may be from cards or the console typewriter. The card deck can be used for both passes, but since only card input is allowed for pass II, typewriter input to pass I requires that a source program card deck be punched as an output to pass I to serve as an input to pass II.

Error messages are typed out for both passes. The typewriter output for pass II may consist of the object program with error messages, or error messages only, as determined by the switch settings indicated in Figure 12.

The output of pass II is an object program card deck in either condensed or uncondensed form (see Figure 12 for switch settings). The condensed object deck contains

machine language instructions only, with up to five instructions per card. The uncondensed deck contains both symbolic cards and machine language cards for each statement. Both the condensed and uncondensed card decks contain the loader and arithmetic tables.

After an uncondensed object deck is obtained from pass II a condensed deck may be punched immediately by processing the source cards a third time (see operating instructions). If the third pass is omitted a condensed deck can be obtained from an uncondensed deck by use of the Condenser Program (Ref 5:82-83).

V. Operating Procedures

A. Changes to the Operating Procedures. There are four major changes to the operating procedures for the IBM 1620 SPS. These are:

1. A record mark is not required at the end of a statement when utilizing typewriter input.

2. With switch 1 ON for a listing on the console typewriter during pass II, if either the page-line field and/or the label field are blank, the typewriter will tabulate rather than space to the proper position for type-out of the statement. A space is inserted between the page-line field and the label field during type-out of the listing.

3. After 60 lines of typing, a skip over the

break in the forms will be accomplished by the execution of six carriage returns.

4. The procedure for the use of switch 4 to punch an object program has been altered.

B. Operating Instructions.

1. Clear Memory (this should be done whenever there may be digits in memory with bad parity).

a. Set all check switches to PROGRAM.

b. Depress INSTANT STOP and RESET.

c. Depress INSERT.

d. Type 16 00010 00000.
(12 digits, no spaces or punctuation)

e. Depress RELEASE and START (or the R/S key).

f. After the MAR lights have cycled through memory at least once, depress INSTANT STOP.

g. Depress RESET.

2. Load the SPS Processor Program.

a. If the computer is not in manual mode, press INSTANT STOP and RESET.

b. Set the OVERFLOW switch to PROGRAM, all other check switches to STOP.

c. Clear the card reader by removing any cards in the hopper and pressing READER STOP and NON-PROCESS RUNOUT. Then remove all cards from the stacker.

d. Put the Processor deck in the reader hopper.

e. Depress LOAD.

f. When the reader stops on the last two cards, depress READER START.

g. Remove the cards from the read stacker, check for the last card, and put the deck away.

3. Set the program switches as indicated in Figure 12 (Ref 14:8-9).

4. Typewriter Operation. During pass II, with program switch 1 ON, the typewriter types each statement alphamerically starting at the left margin. After the last character is typed the typewriter tabulates to the place where typing of the storage address and the assembled machine language instruction should begin. Statements are typed in the format entered except that there is a space between the page-line field and the label, and before and after the operation code field. If either the page-line and/or the label field are missing the typewriter will tabulate to the proper position to continue type-out of the statement (Ref 5:91).

The typewriter will type 60 lines of output and then execute six carriage returns to skip over the seam in the paper.

To set up the typewriter, the operator must:

a. Set right and left hand margins.

b. Set tab stops 6,13, and 56 spaces from the left margin. (Note: positions 6 and 13 are fixed. Position 56 may be varied to locate a position a few spaces to the left of the longest statement).

c. Set paper in the typewriter three lines (three single space carriage returns) below the top of the page.

5. If typewriter input is to be used, the card punch must be readied to punch a source program card deck

as an output for pass I.

a. Clear the punch by lifting the cards from the hopper and pressing NON-PROCESS RUNOUT.

b. Discard any cards that are in the stacker.

c. Load sufficient blank cards into the hopper.

d. Depress PUNCH START (Ref 14:9).

6. Processing the Source Program

PASS I. After the processor is loaded the program halts. Processing starts when the first statement of the source program is read into the computer and START is depressed.

Typewriter Input:

a. Type statement.

b. Depress RELEASE and START keys.

c. Repeat steps a and b until all statements are entered.

Card Input:

a. Place source program card deck in the read hopper and depress READER START.

b. Depress START. Processing proceeds according to the setting of the program switches.

c. When the reader stops, depress READER START to read the last two cards.

The message "END OF PASS I" is typed out at the end of pass I and the symbol table is printed. The operator may supress the symbol table type-out by turning program switch 4 ON while the message "END OF PASS I" is being typed. The program halts after type-out of the symbol table (or when switch 4 is turned ON) to allow preparation

for pass II as described below.

PASS II. The source program card deck used in pass I (or the one punched during pass I if typewriter input was used) is used as the input to pass II.

Card Input Only:

a. Put the source deck in the read hopper and depress READER START.

b. Set program switches for pass II (see Figure 12). Switch 4 must be ON to punch an object deck.

c. If an object program is to be punched, ready the punch as outlined in item 5 and depress PUNCH START.

d. Depress START to begin processing.

After pass II is completed the message "LOAD SUBROUTINES" is typed out if subroutines are required by the source programs. If the subroutines are not required the message "END OF PASS II" is typed and the program halts (Ref 5:92).

Loading the Card Subroutines:

a. Place the subroutine card deck in the read hopper and depress READER START.

b. Depress START.

If the subroutine deck being loaded is variable length, the message "ENTER MANTISSA LENGTH" is typed and the program halts. The operator must enter the 2-digit mantissa length (which may range from 02 to 45; a mantissa length of 08 does not have to be entered) from the console typewriter. Processing is resumed by depressing RELEASE and START. The programmer must insure that the number

(length of mantissa) is correct, but program switch four may be used to correct an erroneous entry. (see Figure 12)

Only those subroutines needed by the source program are punched out as part of the object program. After the subroutines are processed the message "END OF PASS II" is typed out and the program is completed (Ref 5:92-92).

7. When the message "END OF PASS II" is typed out, the object deck, if one was being punched, is also complete. The object deck can be removed from the punch by the following procedure:

a. Lift the blank cards from the punch hopper.

b. Depress the NON-PROCESS RUNOUT key for a few seconds.

c. Remove the deck from the stacker and discard the two blank cards at the end (Ref 14:9).

8. Assembling Other Programs. Upon completion of pass II, a condensed object program deck can be obtained by:

a. Turning program switch 3 ON. (Other switches are set according to Figure 12).

b. Placing the source cards in the read hopper and depressing READER START and PUNCH START.

c. Depressing START (Ref 5:93).

VI. Error Handling Procedures

A. Changes to the Error Handling Procedures. The

following is a list of the significant differences concerning error message and correction techniques between IBM 1620 SPS and the AFIT Version of 1620 SPS.

1. An additional error check has been added and the error 10 message has been redefined to account for this check.

2. The error message "adjustment count" has been renumbered to start at one instead of zero, if an error occurs before a label has been defined.

3. An undefined symbolic address, as a result of misspelling or omission, can be defined during pass II and placed in the symbol table.

4. The effects of errors on the assembly process with program switch 2 off have been altered for error messages 1,3,5, and 11.

B. Error Messages. The error message codes that may be typed out on the typewriter during pass I and/or II are identical with error messages of the IBM 1620 SPS except for the modification of error message 10 described below.

ER10

a. A duplicate label is defined (defined more than once) - Pass I and Pass II.

b. Incorrect address - Pass II. The address in core storage as assigned in the symbol table during Pass I differs from the address present in the address counter when the statement was processed during Pass II.

As a result of this modification if a card is lost from or misplaced in the source deck between pass I and pass II, an address check comparison will cause type-out of error message code 10 during pass II. During pass II this check is made only when switch 2 is OFF. A multiply defined label that is not corrected between pass I and pass II will cause an error indication during pass II.

In the AFIT Version of 1620 SPS Error Messages have the following form:

LABEL		ADJUSTMENT COUNT	ERROR CODE
XXXXXX	+	XXXX	ERn

Where Label refers to the last defined label and the "adjustment count" refers to the number of statements between that label and the statement in error. If an error occurs before any label has been defined (for instance on the first instruction) the LABEL field is blank and the number in the "adjustment count" is typed out. This number is one on the first instruction (rather than zero as in the IBM 1620 SPS) and goes up by one for each statement processed.

C. Error Correction. Error correction procedures are similar to the IBM 1620 SPS, but there are two significant changes which increase the flexibility of the processor. The first change, which is described below, is the ability to define a symbol during pass II.

The SPS processor places symbols in the symbol table during pass I. However, if through a typographical error or omission a symbol is still undefined at the end of pass I, the processor will accept a definition of the symbol during pass II.

During the second pass, the addresses of the instruction operands are evaluated. If the address is symbolic the symbol table is searched for equivalence, and if the symbol is not found it is undefined and an error message (ER 5) is typed.

With program switch 2 ON, the processor stops after typing the error message so that the undefined symbol can be entered into the symbol table. The procedure to define a symbol at this time is described below:

1. To define a symbol during pass II it is necessary to determine the address of the statement from which a label has been omitted. If this statement has been processed and listed on the typewriter, the address of the unlabeled statement can be read directly from the storage address of the assembled instruction.

If the unlabeled statement has not been listed, the symbol table listing and the program source statements prepared on the SPS coding sheets provide a means to determine the address of the unprocessed statement.

In this case the procedure is to examine the coding sheets to determine the number of intervening instructions

between the nearest defined label and the unlabeled instruction. The address of the unlabeled instruction can be designated by using address adjustment with the symbolic label of the nearest instruction, or by adjusting the storage address of the nearest label as determined from the symbol table listing.

If the undefined symbol had been misspelled rather than omitted the address of the unlabeled instruction does not have to be determined. The procedure for defining symbols under both of these circumstances is explained in the next step.

2. If the undefined label was omitted from an instruction, type the following statement: LABEL DS, XXXXX, where label is the undefined symbol and XXXXX stands for the address, symbolic or actual, of the statement from which the label has been omitted.

If the undefined symbol had been misspelled rather than omitted, the following technique can be utilized: Assume, for example, that many references are made to the symbol FABLE, but the defining statement lists the symbol as FABEL. This can be corrected by typing the statement FABLE DS, FABEL. This will cause the processor to define the symbol FABLE to have the same address as FABEL and to enter this symbol into the symbol table (Ref 1:4-5).

A similar procedure can be utilized to define the labels of declarative statements at areas following the last assigned storage space in the symbol table. Determination of the last assigned address can be made by examining the symbol table listing (which was typed at the end of pass I) to secure the address of the last defined label.

3. Remove the remainder of the source deck from the reader hopper and depress NON-PROCESS RUNOUT.

4. Insert the unprocessed cards and the statement for which the error message was printed in front of the unprocessed portion of the source deck and place in the reader hopper. Depress READER START.

5. If no object deck is being punched (switch 4 OFF) depress RELEASE and START.

6. If an object deck is being punched (switch 4 ON).

   a. Depress RELEASE.

   b. Turn switch 4 OFF.

   c. Depress STOP/SIE once.

   d. Turn switch 4 ON.

   e. Depress START.

7. The symbol with its defining address will be placed in the symbol table, the statement that contained the undefined symbol and the remainder of the source deck will be processed.

The second change concerns the effect of errors on the assembly process. With program switch 2 OFF, the processor does not stop for an error correction, but the errors affect the assembly process. The changes to the IBM 1620 SPS processor are described below:

ER 1 - A NOP instruction, 410000000000, is assembled. If the record mark is in the op code field the label, if non blank, is placed in the symbol table. If the record mark is in the label field the label is treated as a blank.

ER 3 - A NOP instruction, 410000000000, is assembled. The label field, if non blank, is placed in the symbol table.

ER 5, ER 11 - Only the symbol in error is assembled as a 00000 (zero) address; the remainder of the operand is evaluated and assembled for output.

VII. Modifying the Processor for Additional Storage

The AFIT Version of 1620 SPS automatically adjusts itself to the size of memory; therefore, no modification of the processor card deck is required when additional storage is provided by the IBM 1623 Core Storage Unit.

VIII. SPS Listing on the IBM 870

The IBM 870 can be used to make an SPS listing from an SPS object deck. The format is similar to the typewriter listing on the 1620 console except for the following exceptions: (1) a flagged zero is typed as

a +, (2) the flagged digits 1-9 are typed as J-R, respectively, and (3) the first digit of the page-line field is not typed.

To facilitate operation of the IBM 870 for this purpose the object deck card format has been altered in the AFIT Version of 1620 SPS. The page-line field on object deck cards punched by the AFIT processor has been changed to provide: (1) The number "6" in the first column of a source statement card, (2) The number "9" in the first column of a numeric instruction card.

In order to save the first digit of the page-line field (located in the first column of a card) for a listing on the IBM 407 the page-line field has been further altered as follows: (1) The first digit of the page-line field on the source statement has been placed as the second digit in the page-line field on the numeric card, and (2) The second digit on the source statement card (which is identical on the numeric instruction card) is preserved in position. Since the IBM 407 control panel can be wired to replace the digits in their proper position in the page-line field an unaltered listing can be obtained.

The operating instructions for preparing an SPS listing

from an SPS object deck on the IBM 870 are as follows:

1. Clear all cards from the machine.

2. Insert the SPS drum card and lower the star wheels.

3. Make sure the "SPS list control panel" is in the machine.

4. Turn the Auto Feed switch ON.

5. Insert the deck to be listed in the hopper.

6. Make sure blank paper is in the typewriter, and the carriage is in its leftmost position.

7. Press the FEED key twice.

8. The listing will begin. To stop before it is finished, use the same procedure as for other types of listing. After the DEND statement and its associated address have been typed out, the listing should be stopped and the rest of the cards removed. If these cards are allowed to list, most of them will simply pass through the machine without listing, but some of them may cause erroneous listings. In addition, this takes extra time (Ref 16:2-3).

IX. Control Operations

A new pseudo-op designated MORG has been added to the AFIT processor. Through this operation the programmer is able to exercise more control over addresses assigned by the processor.

This pseudo-op instructs the processor to define the origin to be the next larger multiple of the given operand. An example is given below:

```
          DORG  4140
          BB
          MORG  100
X         DS    5
```

The MORG pseudo-op defines the origin to be 4200 and causes the next sequential instruction to be loaded in this position. In this case the symbol X would be assigned the address 4204 (Ref 13:1).

X. Macro-Operations

Two new macro-operations that were written by Lt. Pratt and added to the IBM 1620 SPS processor in use at the Institute of Technology have been incorporated in the AFIT Version of the SPS processor. These are used for conversion of floating point numbers from the internal form to the external form, and vice versa. The two macro-operations are called by using the names (1) INC - INput Conversion, and (2) OUTC - OUTput Conversion. These names appear in column 12, just as with other macro-operations (Ref 15:1).

XI. Miscellaneous

Additional Features. The following features which

were not present in the IBM 1620 SPS have been added to the AFIT processor.

When a source deck is being punched during pass I and statements are being entered from the console typewriter, if switch 1 is turned on to complete entry of the source statements from the card reader, the last entry from the typewriter will be punched in the source deck.

Extensive labeling has been accomplished. Use of the address adjustment procedure was reduced, thus increasing the number of symbols in the program. This was done to improve the readability of the processor program and as an aid to modification and recoding.

Operation of Program Switches. The operation of the program for the AFIT Version of 1620 SPS is outlined in Figure 12 on page 97. The two major changes are (1) Switch 4 has to be ON to punch an object program, and (2) with switch 2 on the procedure for correction of statements containing error messages has been altered.

SWITCH	PASS I		PASS II	
	ON	OFF	ON	OFF
1	Card Reader Input.	Typewriter Input.	Input statement and the assembled machine language instruction are typed out.	Listing is not typed.
2	After an error message is typed the computer stops so that a corrected statement can be entered at the typewriter.	After an error message is typed, the error is adjusted by the processor and processing continues.	Same as pass I. To continue processing after corrected statement has been entered; With SW 4 ON: press RELEASE, turn SW 4 OFF, press STOP/SIE once, turn SW 4 ON, press START. With SW 4 OFF: press RELEASE and START.	Same as pass I.
3		Switch must be off when assembling a program.	Condensed object program.	Uncondensed object program.
4	To correct a typing error made while entering a statement: Turn ON, Depress RELEASE and START. Turn OFF, and re-enter entire statement at typewriter.	Switch should be off when assembling a program.	Object program is punched. (Same as pass I for correction of typing errors).	No object program is punched (used to pre-edit a source program).

Fig. 12

Operation of Program Switches

Flow Diagram Changes. The principal changes to the flow diagrams for the IBM SPS Processor are in (1) the input routines, (2) the routine to load labels into the symbol table, and (3) the DEND/TCD routine. In addition, since the symbol table can now be entered during pass II, all routines proceed to the Load Label routine rather than to pass II as indicated on the IBM SPS processor flow diagrams. Consequently except for the flow diagrams in Figures 18, 19, and 20, if the symbol PASS II is changed to read LOAD LABEL on all IBM SPS processor flow diagrams, the diagram will be compatible with the AFIT Version of 1620 SPS.

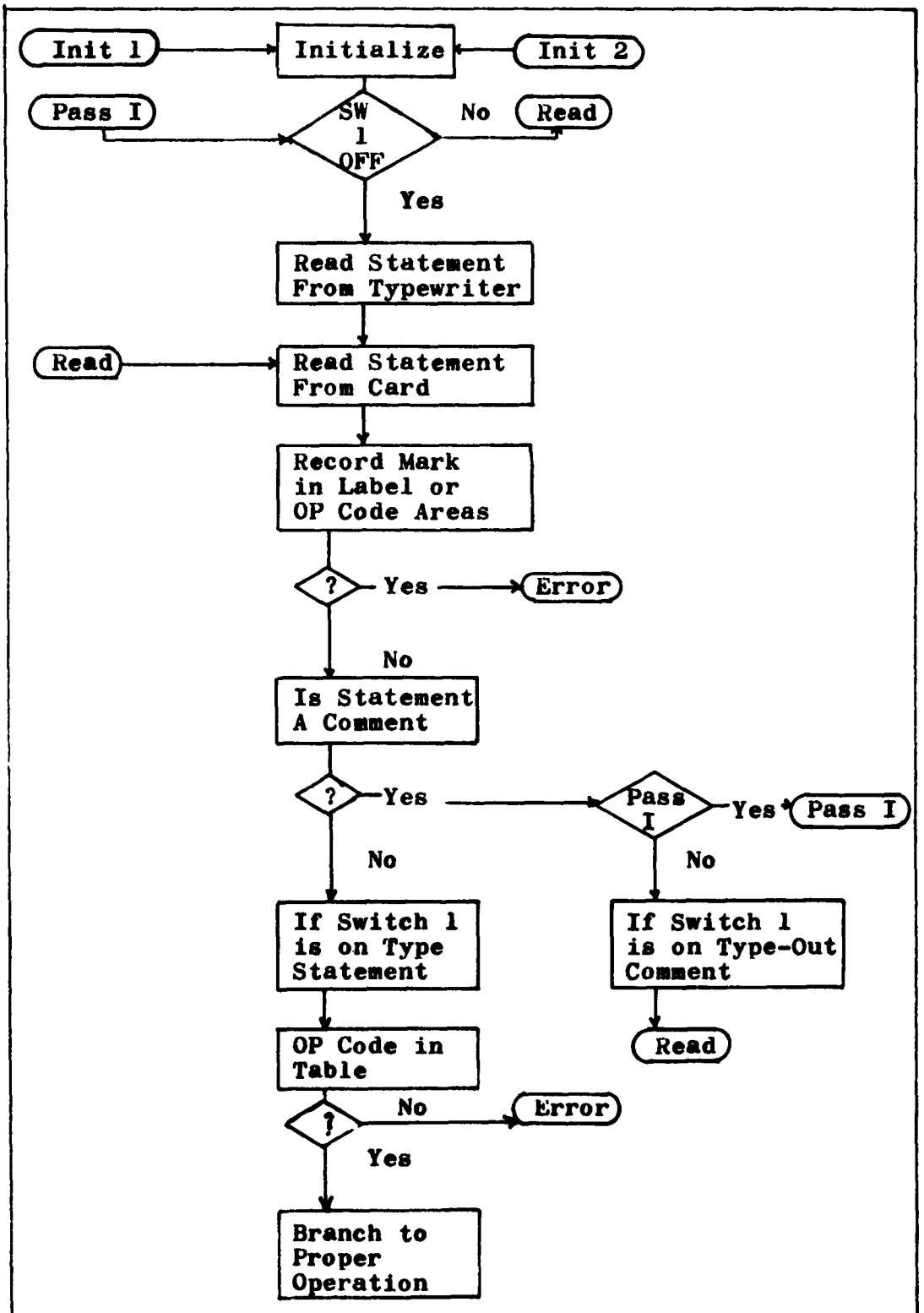

Fig. 18
Input Routine Flow Diagram

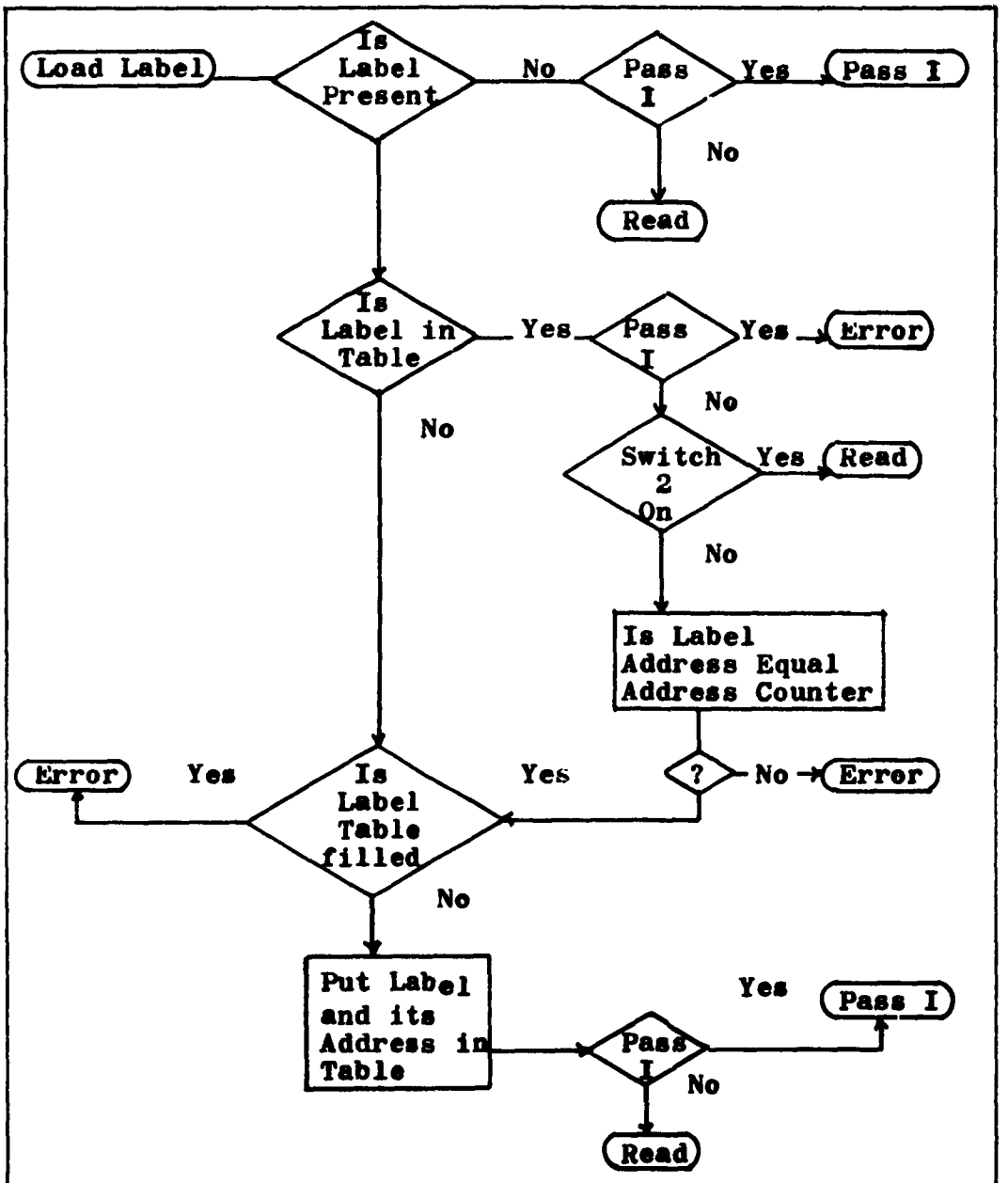

Fig. 19

Load Label Routine Flow Diagram

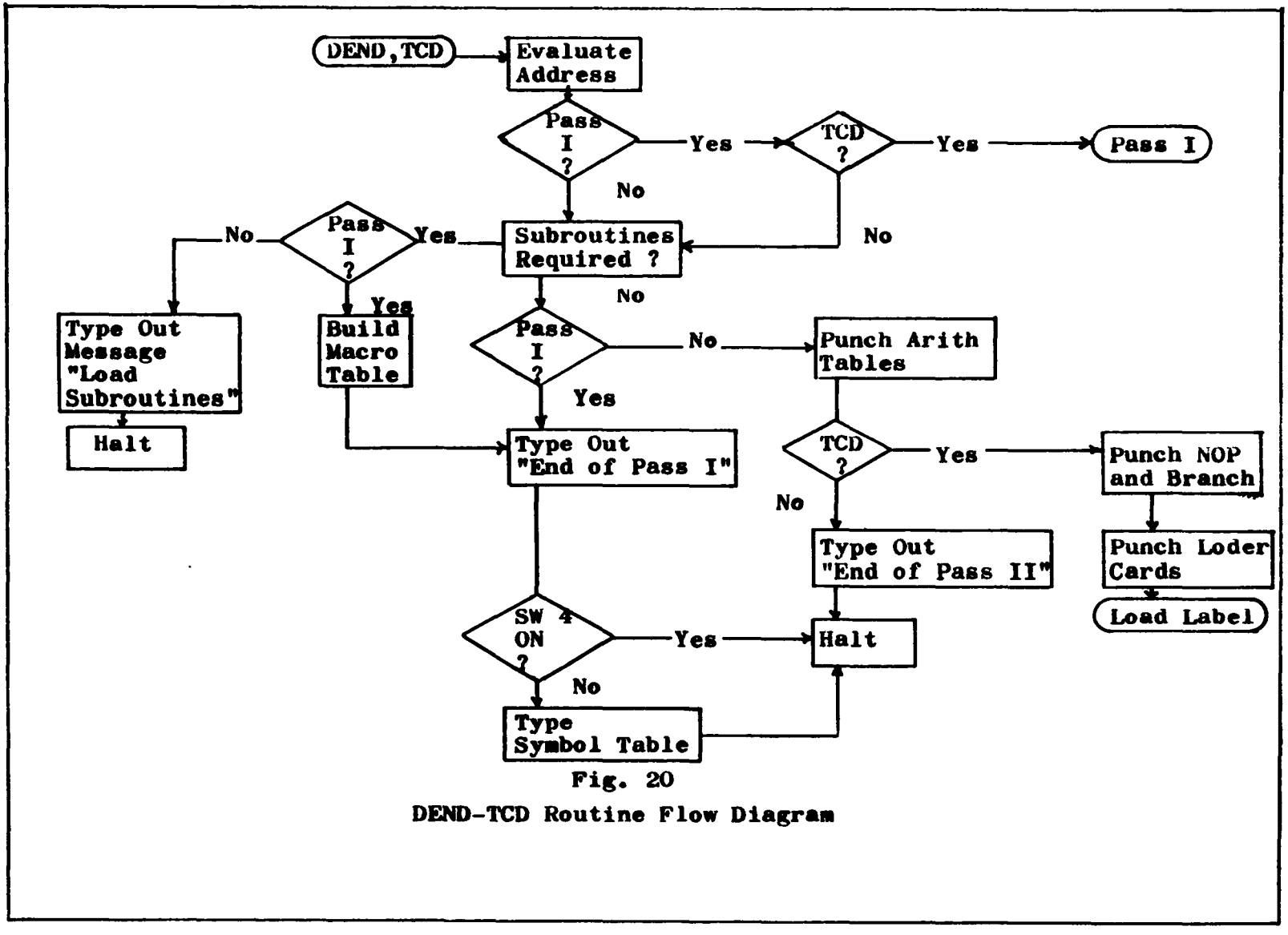

Fig. 20

DEND-TCD Routine Flow Diagram

Appendix C

Label Reference Index

Appendix C contains a printed listing of the Label Reference Index object program that was assembled at the School of Logistics 1620 computer facility using the IBM 1623 Storage Unit. The printed listing was prepared from the object program using the IBM 407.

The Label Reference Index is a list of all symbols in the processor program and of all card numbers in the program which refer to each symbol.

```
10005*          SPS PROCESSOR FOR AFIT VERSION 1620 CARD 170, DATED 11/17/62
27435     A     13125
11835     AA1   11885
12215     AA2   12205 12225 12235 12245
28905     AA3   28895 28915 28925 28935
20555     ABLE  20385 20405 20495
11745     ADDRS 13605 14225 14275 14345 15595 16935 17265 17635 17645 17655
                17795 17825 17835 18705 18715 18725 18745 19285 19295 19735
                19925 19985 20005 20765 20775 20835 21005 21245 21275 21275
                21285 21735 21815 21915 22025 22085 22115 22265 22375 22405
                22435 22545 22575 22615 22695 22715 22915 22925 23055 23455
                23465 23475 24385 25025 25075 25105 25235 25615 25715 25755
                25805 26565 26725 26735
25705     AERB
10155     AJUST 19715
13125     ALFOP 13065
10055     ALPHA 13635 14225 14835 14845 14875 14955 15075 15215
14225     AORS  13665 14195 14235
22155     ASINE 22035
14995     ASTER 13825
22445     A1    22415 22505
15945     A10   16125
14035     A11   13755 14165 14485
13725     A12   14265 15035 15105 15135
13875     A13   14115
14025     A14   14495
14785     A15   14825
16645     A16   16335
16515     A17   16475 23005
16365     A18   16735
16305     A19   16765
11815     A2    11785 11795 11805 11835
17945     A21   17815 17815
18105     A22   18225
18515     A23   18385
18565     A24   18635
19055     A25   19005
18745     A26   19145 19185
19605     A27   19575 19685
19675     A28   19785
20635     A29   20645 20875
11795     A3    11845
21575     A32   21525
21935     A33   21975
24445     A34   21955
```

22075	A35	22155
22375	A36	22465
12425	A37	25985 26765
23105	A38	22875 22895
12355	A4	12385 15535
23555	A41	23095 23165
23875	A42	
23235	A43	23515 23535
23255	A44	23525
24085	A45	24015 24075 24095
24155	A46	24055
24025	A47	24065 24135
23175	A48	24175
12985	A49	12955
16825	A5	12525 12525 12545 12545 23575 23575 23595 23595 23705 23705 23805 23805
24745	A50	24575
24695	A51	24585
24835	A52	24795
25115	A53	25085 25255 25295
25565	A54	25335
25525	A55	25565
25655	A56	25465 25605
25625	A57	25485
25715	A58	25655
25755	A59	25675 25705
13215	A6	12115 13015
26095	A60	26035 26045
26035	A61	26075
26215	A62	26145 26165
15285	A63	15275 15415 15485 15415 15425 26615 26645
16215	A64	16175 26435 26485 26525
15515	A7	13225 15555 16225 24465 25445
24735	A70	24545
15965	A8	22705
15955	A9	16015 16235
20485	BAKR	20435
16875	BB	15395 16505 16815 16825 17895 17905 17945 19365 19415 22985
14365	BBACK	14355
23885	BETA	13625 14255 14875 14965
19525	BI	13515
26375	BIT	26265
17575	BLKVR	17515 17525 17535 17595
27055	BLNKS	12705 16605 16995 17255 17275 18305 18495 23645
11405	BLSND	17625

19535	BNI	13515
17145	BRNCH	17085 17095
27265	BRSQ	23555 23565
21135	BR1	21115 21165
21155	BR2	21125
13535	BTBL	13435
11685	B1	11665 11675 11695
13145	B10	13125 13135
16115	B12	16055
13965	B13	13885
14185	B14	14155
14235	B15	14185
14345	B16	14285
14425	B17	14385
14455	B18	14405
14655	B19	14595
11675	B2	11705
14685	B20	14655 14665 14675
14825	B21	14815
14945	B22	14895
15645	B23	15615
15615	B24	15675
15755	B25	15735
15795	B26	15745
15855	B27	15835
15875	B28	15865
16465	B29	16435 16445 16455
11875	B3	11825
16495	B30	16465
16595	B31	16535
16695	B32	16655
16665	B33	16705 16725
15215	B38	15195 15205
17305	B39	17295
12455	B4	12415
17415	B40	17395
17555	B41	17545 17565 17575 17585
17605	B42	17595
18125	B45	18095 18115 18145
18195	B46	18165
18165	B47	18145 18155
18955	B48	18925
19665	B49	19655
19715	B50	19705
19725	B51	19715

19885	B52	19845
19975	B53	19945
20065	B54	20025
20245	B55	20105
20175	B56	20165
20325	B57	20295
20355	B58	20325
20425	B59	20395
12695	B6	12675
20295	B60	20465
20535	B61	20505
20565	B62	20555
20705	B65	20685 20695
20875	B66	20855 20865 20895
20865	B67	20885
20915	B68	20895 20905
21325	B71	21295
21355	B72	21325
21415	B73	21385
21445	B74	21415
21465	B75	21425
21495	B76	21485
21555	B77	21535 21545
21605	B78	21585 21595
21645	B79	21615 21625 21635 21655
12975	B8	12945
21635	B80	21665
21975	B83	21925
22335	B84	22275
22685	B85	22665
23045	B87	22965
23035	B88	22945
23065	B89	23045
22985	B891	17805 17805 23065 23065
12005	B9	12035
23665	B90	23655
23685	B91	23675
23725	B92	23715
23355	B93	23305
23365	B94	23355 23375
23455	B95	23445
23505	B96	23485
24115	B99	24095 24105
20455	CHAR	20605
25165	CHECK	24985

15385	D26	15195 15335 15345 15355 15405 26545
15405	D27	15375
15365	D28	
15395	D29	
24515	D3	24415
26545	D30	26405
26565	D32	26545 26555
15295	D33	15175 26375
26745	D34	26575
24635	D4	24605
24825	D5	24805
24875	D6	24855 24865 24895
24905	D7	24895
24955	D8	24915
24985	D9	24955
10135	EJS	11545 11645 12105 12425 12455 12605 13305 15495 15745 15955 19845 21765 22135 22205 22445 22685 22845 23165 23185 23965 24485 25115 25335 25465 25765 25915 26405
16345	EMPTY	16625
24425	ERCON	21265 21305 21335 21395 21455 22325 24405 24595 24755 24885
25415	ERDSA	25595
11115	ERLAB	11555 15765 26745
12045	ER1	
26415	ER10	26605
14305	ER11	
16145	ER12	16085
16195	ER13	16035
26465	ER14	26185 26245
13195	ER3	
13925	ER5	14735 15175
26505	ER9	26635
15555	EV1	15495
27395	FINAL	11695 15825 17715 26615 28805 28815
21775	F1	21035 21705
21815	F2	21705
21765	F3	21805
26105	F9	25965
14565	GET	14205 15005
14195	GET1	14075
25025	GOAHD	25175
13455	GOODB	13095 13355 13445 17055 25705 25775
13475	GOOD1	13435 13465
13485	GOOD2	13475
26895	GOTO	22915 22955 23035 23785 23795
22655	G1	22585

28805	G10	28755
26615	G11	26375 26585
12305	G13	11725
21065	G14	21055
12165	G15	12365 12365 12585 12585
12885	G16	12805
12915	G17	12835
12925	G18	12865
12825	G19	12895
11895	G20	11795 11855
17255	G22	
12075	G23	12065
13345	G24	13305
19265	G25	19255
13015	G26	12775 12985
23315	G30	23295
14545	G4	15225
19285	G5	18205 19025 19035 19165 19175
28735	G8	28775 28785 28805
28775	G9	28745
26115	HED	11565 13645 14455 14575 14685 15925 16095 16165 26365
12995	H1	12465
11545	INITI	23905 28955
11555	INIT2	23335 23895
26865	INKRM	11575 11995 15525 15775 26755
10335	INPUT	11785 11835 11955 11975 12015 12135 12175 12185 12195 12205
		12235 12375 12595 12685 12785 12825 12925 12945 12975 13055
		13075 13085 13155 13295 13785 13815 13845 13965 14035 14035
		14055 14105 14135 14155 14185 15615 15645 15665 15665 15945
		16005 16045 16065 16095 16115 16115 17205 17215 17225 17385
		17425 17475 17915 18275 19055 19945 20105 20285 20285 20295
		20325 20355 20375 20395 20425 20455 20455 20485 20505 20535
		20555 21045 21125 21155 21225 21295 21325 21355 21575 21605
		21895 21925 22035 22335 24325 24355 24415 24445 24565 24595
		24605 24695 24705 24725 24725 24735 24985 25165 25165 25185
		25185 25525 25555 25555 25565 25635 25955 26015 26745 28865
		28875 28885 28895 28925
27165	INSND	18695
19515	INST	13105 13515
10215	ISTAT	11715 20685 24115 24005 24045
15275	IT	15185 15185 26385 26385
10205	JSTBL	
19705	JUST	13235 13235 19835 19835 20625 20625 21715 21715 23975 23975
		25885 25885
19555	K	13525

22935	L	
11175	LAB	26015 26035 26045 26065 26065 26095 26125 26135 26155 26175
		26195 26225 26225 26235
13985	LABL	13695 13735 13865 14475 14565
15195	LABOK	
15155	LBADD	14575 14635 14705
26225	LBLOK	26205
26255	LDHED	
25955	LDLBL	13315 17435 17845 18535 18645 18935 19865 21765 22135 22205
		22445 22685 22745 25115 25765
17195	LINE	12695 15965 16975 17295 22725 23075
11085	LINK	20815
10235	LNTH	16945 16985 17135 17525 17535 17745 17835 18215 19045 21005
		21015 21245 21255 21515 22075 22085 22105 22265 22285 22385
		22405 24385 24395 24865 25035 25075 25145 25285 25645
22545	LYNN	22555
20625	MACRO	13505
20765	MAC1	25785
11135	MESS1	22805 22865 23175 23825
11145	MESS2	24195
22515	MORG	13545
14875	MULT	14215 14215 15015 15015 15085 15085
22465	NASS	22335
12775	NAST	12105 12665
26455	NOISE	24165
10195	NUMB	14745 14785 14785 14795 14845
13435	OK	13165
10225	ONEZ	13625 14255
13055	OP	12455 24485 24505
12855	ORDER	11595 16545 16555 16835 16845 17955 17975 17985 17995 18005
10065	OUT	18325 18365 18395 18405 18415 18465 18475 18475 18515 18765
		18775 18785 18795 18805 18815 18825 18945 18865 20805 20825
		21375 21385 21415 21445 21465 21515 21575 21615 21655 23605
		23655 23675 23715 23725 23735 23735 23745 24165 25125
22915	OVER	22845
12285	PASS1	12435 13325 15955 22855
18275	PCON	18085 18175 21855 25155
18355	PCON1	18325 18335 18345 18365 18375
18465	PCON2	18395
18505	PCON3	18425
18555	PDSA	18285
16955	PLACE	11985 15515 24475
12515	PLDR	11645 23815
12295	PNCH1	
19505	PRDAS	21035

22455	PRDS	
22215	PRDSB	
19395	PRSW	12285 12315 12675 12775 12985 13365 15565 15735 17035 17095 17325 18085 18755 19005 19145 19355 19375 22705 23045
23225	PRSYM	
17055	PRT1	17035
17085	PRT2	17055
23645	PTBL	23745
19445	RCNT	11605 19405 19425 19455 19475
19355	RCTY	12305 12305 12615 12615 13375 13375 15575 15575 18195 18195 19015 19015 19155 19155 23105 23105 23245 23245
19385	RCTY1	12355 12355 24495 24495 25475 25475 26595 26595
19435	RC2	19465
19545	RDW	13525
12585	READ	12285 12315 12425 12725 15985
11485	RECMK	18355 18405 18595 18795 18805 18815 18885 23185 23665 24825
28945	REC1	28735
12035	RLOP	11975 12005 12015 12065 13295
12135	RMFLL	12025
11065	RMRK	
11785	RSCAN	12405 12405 12625 12625
20165	SEEIM	20115 20245
22035	SEN	
24935	SET	12085 12165 13015
24945	SET2	13925 14305 15605
24775	SFLAG	24535 24635 24695 24745 24785
24975	SIXTY	16325 16495 16595 16715 22995
19625	SNDOP	19565 19595 19665 19765
23305	SNT	23225 23285 23355 23425 23435 23445
19295	SPA1	17045 17045
14135	SPEC	
12405	STAR	12605
28725	START	28975
28955	STRT2	28845
15125	SW2	15065
23395	SYM1	23265 23365 23385 23385 23405
23415	SYM2	23275 23375 23395 23405 23425
13785	S1	14135
19235	TABBY	
27605	TDM	
10035	TEMP	11815 11825 11875 19885
10275	TEMPR	16965 17375 17405 21015 21025 21025 21285 21365 21625 21745 21845 22025
19205	TEST	16305 16315 16395 16445 16495 16715
15055	TEST3	14995

15075	TFADD	15055
14355	TOBB	15605 15625 15655
16385	TR	16365 16375 16395 16435 16615
25885	TRA	13515
11225	TRAC	25905
20285	TRANS	20335 20575
25615	TRDSA	25315 25385 25395 25405 25455 25545 25575 25585 25685
24725	TRREC	24615 24645
26125	TSPEC	26005 26215 26235 26245
12255	TYPE	16345 16645
24195	WRMS	19075 23965
28385	XDAS	21225
28685	XDEND	13175
28445	XDNB	17425
28365	XDS	21895 24325
28425	XDSA	18275 19055
28435	XDSB	17385
28375	XDSS	24355
10105	ZERO	13075 13085 13145 13155 13345 13445 18095 18585 18625 18625
		18635 18765 18775 18785 18875 18885 18895 18905 18925 18955
		18975 18995 18995 19105 19105 19605 19605 19615 19615 19625
		19655 19675 19775 19775 19825 19895 19895 19905 19905 19925
		19935 19985 19995 20165 20195 20215 20445 20565 20595 20635
		20645 20695 20805 20815 20825 20835 20845 20915 20925 20935
		22275 22395 22855 22945 23095 23255 23275 23485 23495 23505
		23815 24315 24365 24515 24525 24705 24715 24715 24745 24775
		24805 24815 24825 24835 24855 24905 24925 24955 24965 25125
		25615 25905
10265	ADDCOW	11585 11985 13245 15075 15515 19705 19725 19735 19855 19885
		20005 20015 21725 21745 21755 22075 22115 22125 22375 22385
		22525 22535 22565 22575 22615 22655 22675 23985 24475 25025
		25035 25045 25655 25665 25675 25685 25695 25725 25895
14055	BCMSPC	13715
27285	BRLOAD	24265
16625	BRRDBB	16515 16665
12665	CASTER	
24565	CCOMER	24735
21375	CHVALD	21355 21365 21475 21485 21535 21585
10295	CLERER	11555 11685 11925 11935 11945 12175 12185 12195 12795 13605
		14275 14885 17485 17495 17505 18105 19825 23255 24515 24875
		25955 28865 28875 28885
16295	CMPCON	18455 18525 18605
16735	CMPINS	18915
11435	CMPOUT	16355 16385 16405 16425 16525 16555 16565 16575 16585 16605
		16615

14065	COMMER	13795
14105	COMSPC	14055
27065	CONSND	18315 21815 21825 21835 21835 21845 25045 25055 25135 25135
		25145 25235 25255 25285
18695	DOINST	17065
14385	DOLLAR	13855
27115	DSASND	18555 20765 20775 20785 20795 25805 25815 25825 25825 25835
11195	ELNGTH	24445
11475	ENTABL	20855 24015
15735	EPRINT	13215 13215 15485 15485 16215 16215 24455 24455 25435 25435
14525	ERCHAR	14435
13605	EVALAD	13615 13655 13715 14015 14195 14245 14355 14465 14995 15025
		15055 15065 15095 15125 19915 19975 20995 21235 21805 21905
		22015 22195 22255 22505 22515 22605 22795 24375 25225 25375
15485	EVALER	12045 13195 13945 14325 14525 14925 15795 16145 16195 21935
		24425 25415 26415 26465 26505
20105	FLAGGR	19515 19635
25375	GOEVAL	25325 25625 25635
15925	HEADER	13545 15935 16035 16105
11025	INPUT2	11925 11935 11945 11955 12295 12515 12535 12705 15825 15845
		16305 16315 16345 16355 16365 16375 16405 16415 16645 16695
		16845 16855 16865 16985 16995 17205 17215 17225 17235 17245
		17255 17265 17275 17285 17405 17475 17485 17495 17505 17515
		17545 17625 17655 17665 17675 17685 17695 17735 17755 17765
		17775 17785 17795 17925 17935 17965 17975 17985 17995 18005
		18015 18025 18305 18315 18335 18345 18415 18425 18435 18435
		18445 18485 18485 18495 18505 18515 18555 18565 18575 18585
		18595 18615 18695 18715 18725 18735 18895 19065 19075 19115
		19125 19125 19135 22885 23555 23565 23585 23645 23685 23695
		23785 23795
11465	INPUT3	15165 15385 26095 26105 26275 26295 26695
19825	INSTRN	19515 19525 19535 19545 19555 20025
25975	LABCTR	15155 15365 26025 26055 26255 26285 26655 26665 26665 26685
15935	LINPRT	13365 13385 17085 19505 20185 20205 20225 20305 20365 20945
		21855 22145 22215 22455 25155 25845 25915
11235	LODER1	12515 28825
11325	LODER2	12535 28835
11155	LOPOUT	12785 12795 12825 12835 12885 12915 12925 12935
23965	MACROS	23155
10255	NOPREC	13345
21715	NOSINE	21055 21065 21795
18875	NOTYPE	18755
17895	PCHALF	17195 17195 17235 17915
16815	PCHCRD	12715 12715 15855 15975 15975 17415 17415 18295 18295 22735
		22735 23085 23085

13005	PICKUP	20845 24155
22885	PNCH11	
25155	PRDCSA	
16525	PUNCHY	16675
14265	RETURN	13675 14065
19105	SECINS	18965 18985
15315	SEIFIN	15285
23325	SEVENS	17965
22565	SHFILA	22535 22545
21455	STCHAR	21465 21675
19225	SUBENT	23985 24115 24125 24155
28695	SYMTBL	11665 15275 23225 28705
19195	TABBYI	13385 15585 18205 19035 19175 19255 24505 25485 26605
27215	TABCON	23605
26785	TBLCRD	23585
14615	TBLEND	
24845	TESTAD	16415 16695
10185	THINGS	13685 13725
26885	TISTAT	11715 23115
14725	TRNUMB	14565
14795	TRNUM1	14755 14765 14775 14815
19315	TYPADD	18125 18135
18085	TYPDSA	19085 25845
20005	TYPINS	19955
15825	WRPRND	15865 18455 18525 18605 18915
20595	ZERONE	20515 20545
28985		

Appendix D

Program Listing

Appendix D contains the final printed listing of the AFIT Version of 1620 SPS. This program was assembled on the IBM 7090 and printed in an off-line operation on the IBM 1401.

```
10005 *        SPS PROCESSOR FOR AFIT VERSION 1620 CARD I/O, DATED 11/1/62
10015 *
10025          ORG 402                                          00402
10035 TEMP     DS   5                                           00406      5
10045          DC   11,'                                        00417     11
               -000000000'
10055 ALPHA    DS   10,*-6                                      00411     10
10065 OUT      DS   1                                           00418      1
10075          DS   60                                          00478     60
10085          DS   10                                          00488     10
10095          DS   10                                          00498     10
10105 ZERO     DC   2,0                                         00500      2
               -0
10115          DS   81                                          00581     81
10125          DC   1,'                                         00582      1
               '
10135 EJS      DS   5                                           00587      5
10145          DC   1,'                                         00588      1
               '
10155 AJUST    DC   11,2121212121                               00599     11
               -2121217121
10165 COLL     DS   19                                          00618     19
10175          DS   2                                           00620      2
10185 THINGS   DC   21,0010203040506070000'                    00641     21
               -0010203040506070C000'
10195 NUMB     DC   7,'                                         00648      7
               -00000'
10205 JSTBL    DC   11,3232323232                               00659     11
               -3232323232'
10215 ISTAT    DC   30,111111111111111111111111111110          00689     30
               J111111111111111111111111111110
10225 ONEZ     DC   10,1                                        00699     10
               -0000000001
10235 LNTH     DS   5                                           00704      5
10245          DC   1,'                                         00705      1
               '
10255 NOPREC   DC   15,410000000000'                            00720     15
               -0410000000000'
10265 ADDCOW   DC   5,0                                         00725      5
               -0000
10275 TEMPR    DS   5                                           00730      5
10285          DC   1,'                                         00731      1
               '
10295 CLERER   DC   1,0                                         00732      1
               -
10305          DSC  25,0                                        00733     25
               0000000000000000000C00000
10315          DSC  28,'                                        00758     28
               0C0000000000000C0C000000000'
10325          DC   10,0                                        00795     10
               -0000000000
10335 INPUT    DS   2,**2                                       00797      2
10345          DC   12,0                                        00807     12
               -00000000000
10355          DC   8,0                                         00815      8
               -0000000
```

```
10365        DC   2,0                                    00817        2
                -0
10375        DC   2,0                                    00819        2
                -0
10385        DC   2,0                                    00821        2
                -0
10395        DC   2,0                                    00823        2
                -0
10405        DC   2,0                                    00825        2
                -0
10415        DC   2,0                                    00827        2
                -0
10425        DC   2,0                                    00829        2
                -0
10435        DC   2,0                                    00831        2
                -0
10445        DC   2,0                                    00833        2
                -0
10455        DC   2,0                                    00835        2
                -0
10465        DC   2,0                                    00837        2
                -0
10475        DC   2,0                                    00839        2
                -0
10485        DC   2,0                                    00841        2
                -0
10495        DC   2,0                                    00843        2
                -0
10505        DC   2,0                                    00845        2
                -0
10515        DC   2,0                                    00847        2
                -0
10525        DC   2,0                                    00849        2
                -0
10535        DC   2,0                                    00851        2
                -0
10545        DC   2,0                                    00853        2
                -0
10555        DC   2,0                                    00855        2
                -0
10565        DC   2,0                                    00857        2
                -0
10575        DC   2,0                                    00859        2
                -0
10585        DC   2,0                                    00861        2
                -0
10595        DC   2,0                                    00863        2
                -0
10605        DC   2,0                                    00865        2
                -0
10615        DC   2,0                                    00867        2
                -0
10625        DC   2,0                                    00869        2
                -0
10635        DC   2,0                                    00871        2
                -0
```

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10645        DC   2,0                                    00873        2
                -0
10655        DC   2,0                                    00875        2
                -0
10665        DC   2,0                                    00877        2
                -0
10675        DC   2,0                                    00879        2
                -0
10685        DC   2,0                                    00881        2
                -0
10695        DC   2,0                                    00883        2
                -0
10705        DC   2,0                                    00885        2
                -0
10715        DC   2,0                                    00887        2
                -0
10725        DC   2,0                                    00889        2
                -0
10735        DC   2,0                                    00891        2
                -0
10745        DC   2,0                                    00893        2
                -0
10755        DC   2,0                                    00895        2
                -0
10765        DC   2,0                                    00897        2
                -0
10775        DC   2,0                                    00899        2
                -0
10785        DC   2,0                                    00901        2
                -0
10795        DC   2,0                                    00903        2
                -0
10805        DC   2,0                                    00905        2
                -0
10815        DC   2,0                                    00907        2
                -0
10825        DC   2,0                                    00909        2
                -0
10835        DC   2,0                                    00911        2
                -0
10845        DC   2,0                                    00913        2
                -0
10855        DC   2,0                                    00915        2
                -0
10865        DC   2,0                                    00917        2
                -0
10875        DC   2,0                                    00919        2
                -0
10885        DC   2,0                                    00921        2
                -0
10895        DC   2,0                                    00923        2
                -0
10905        DC   2,0                                    00925        2
                -0
10915        DC   2,0                                    00927        2
                -0
```

```
10925          DC   2,0                                    00929          2
               -0
10935          DC   2,0                                    00931          2
               -0
10945          DC   2,0                                    00933          2
               -0
10955          DC   2,0                                    00935          2
               -0
10965          DC   2,0                                    00937          2
               -0
10975          DC   2,0                                    00939          2
               -0
10985          DC   2,0                                    00941          2
               -0
10995          DC   2,0                                    00943          2
               -0
11005          DC   2,0                                    00945          2
               -0
11015          DC   2,'                                    00947          2
               -'
11025 INPUT2   DS   12                                     00959         12
11035          DS   152                                    01111        152
11045 ADDRS    DS   11                                     01122         11
11055          DC   1,'                                    01123          1
               '
11065 RMRK     DS   3                                      01126          3
11075          DC   1,'                                    01127          1
               '
11085 LINK     TFM  11,23,27                               01128  16  -0011  -0023
11095          B                                           01140  49  00000  00000
11105          DC   1,'                                    01152          1
               '
11115 ERLAB    DAS  6                                      01155          2 X    6
11125          DAC  2,+'                                   01167          2 X    2
               +'
11135 MESS1    DAC  15,END OF PASSII '                     01171         15 X    2
               END OF PASSII '
11145 MESS2    DAC  17,LOAD SUBROUTINES'                   01201         17 X    2
               LOAD SUBROUTINES'
11155 LOPOUT   DS   12                                     01245         12
11165          DC   4,'                                    01249          4
               -00'
11175 LAB      DS   12                                     01261         12
11185          DC   1,'                                    01262          1
               '
11195 ELNGTH   DC   2,75                                   01264          2
               P5
11205          DC   2,70                                   01266          2
               PG
11215          DC   2,'                                    01268          2
               -'
11225 TRAC     DC   26,360000000500490000000000'           01294         26
               -360000000500490000000000'
11235 LODER1   RNCD 72                                     01296  36  00072  00500
11245          RNCD 201                                    01308  36  00201  00500
11255          BNF  12,276                                 01320  44  00012  00276
```

```
11265          TF    59,274                                  01332  26  00059  00274
11275          TD    11                                      01344  25  00011  00000
11285          TF    90,269                                  01356  26  00090  00269
11295          DNB   3                                       01370          3
11305          DC    1,0                                     01371          1
               -
11315          DC    4,'                                     01375          4
               -00'
11325 LODER2   TF    95,264                                  01376  26  00095  00264
11335          TR    ,200                                    01388  31  00000  00200
11345          TF    114,274                                 01400  26  00114  00274
11355          TD    ,11                                     01412  25  00000  00011
11365          B     12                                      01424  49  00012  00000
11375          DNB   15                                      01450          15
11385          DC    1,0                                     01451          1
               -
11395          DC    4,'                                     01455          4
               -00'
11405 BLSNC    DAC   12,-7J0000J0000                         01457          12 X     2
               -7J00C0J0000
11415          DC    4,50                                    01483          4
               -C50
11425          DAC   5,     '                                01485          5 X     2
               '
11435 CMPOUT   DS    1                                       01494          1
11445          DNB   50                                      01544          50
11455          DNB   29                                      01573          29
11465 INPUT3   DS    12                                      01585          12
11475 ENTABL   DSB   7,30                                    01592          7 X     30
11485 RECMK    DC    1,'                                     01796          1
               '
11495 *
11505 *          INITIALIZATION FOR PASSI AND PASSII
11515 *          PASSI STARTING POINT IS INITI
11525 *          PASSII STARTING POINT IS INIT2
11535 *
11545 INITI    TDM   EJS                                     01798  15  00587  00000
11555 INIT2    TF    ERLAB+10,CLERER+11                      01810  26  01165  00743
11565          TFM   HED,,10                                 01822  16  14341  000-0
11575          TFM   INKRM,0                                 01834  16  15082  -0000
11585          TFM   ADDCOM,401                              01846  16  00725  -0401
11595          TFM   ORDER,9999,8                            01858  16  02865  0R999
11605          TFM   RCNT,60,10                              01870  16  08709  00000
11615 *
11625 *          BRANCH IF PASSII
11635 *
11645          BC    PLDR,EJS                                01882  43  02586  00587
11655 *          CLEAR SYMBOL TABLE AREA
11665          TFM   B1+6,SYMTBL-6                           01894  16  01924  J6812
11675 B2       AM    B1+6,6,10                               01906  11  01924  000-6
11685 B1       TR    ,CLERER+47                              01918  31  00000  00779
11695          C     B1+6,FINAL                              01930  24  01924  15431
11705          BL    B2                                      01942  47  01906  01300
11715          TF    ISTAT,TISTAT                            01954  26  00689  15113
11725          B     G13                                     01966  49  02450  00000
11735          DORG  *-3                                     01974
```

```
11745 *
11755 *          FIND RIGHTMOST CHARACTER OF STATEMENT AND PLACE A
11765 *          RECORD MARK AFTER IT
11775 *
11785 RSCAN   TFM   A2+11,INPUT+140                    01974  16  02021  -0937
11795 A3      TF    G20+6,A2+11                        01986  26  02096  02021
11805         SM    A2+11,2                            01998  12  02021  -0002
11815 A2      TF    TEMP                               02010  26  00406  00000
11825         BNR   B3,TEMP                            02022  45  02066  00406
11835 AA1     CM    A2+11,INPUT+20                     02034  14  02021  -0817
11845         BH    A3                                 02046  46  01986  01100
11855         B     G20                                02058  49  02090  00000
11865         DORG  *-3                                02066
11875 B3      CM    TEMP,,10                           02066  14  00406  000-0
11885         BE    AA1                                02078  46  02034  01200
11895 G20     TFM                                      02090  16  00000  -0000
11905         DC    2,',*                              02101          2
              -*
11915 *          CLEAR AREA FOR PUNCHING OUT SOURCE STATEMENT
11925         TR    INPUT2-1,CLERER                    02102  31  00958  00732
11935         TR    INPUT2+52,CLERER                   02114  31  01011  00732
11945         TF    INPUT2+148,CLERER+46               02126  26  01107  00778
11955         TR    INPUT2-11,INPUT-11                 02138  31  00948  00786
11965 *          CHECK FOR RECORD MARK IN LABEL OR OPCODE FIELD
11975         TFM   RLOP+11,INPUT-2                    02150  16  02233  -0795
11985         TF    PLACE,ADDCOM                       02162  26  06365  00725
11995         AM    INKRM,1,10                         02174  11  15082  000-1
12005 B9      AM    RLOP+11,2,10                       02186  11  02233  000-2
12015         CM    RLOP+11,INPUT+20                   02198  14  02233  -0817
12025         BE    RMFLL                              02210  46  02302  01200
12035 RLOP    BNR   B9                                 02222  45  02186  00000
12045 ER1     TFM   EVALER-1,10000                     02234  16  05105  J0000
12055         DC    1,',*                              02245          1
              *
12065         TF    G23+6,RLOP+11                      02246  26  02264  02233
12075 G23     TDM   ,0                                 02258  15  00000  00000
12085         TDM   SET,                               02270  15  13313  00000
12095         DC    1,',*                              02281          1
              *
12105         BC    NAST,EJS                           02282  43  02774  00587
12115         B     A6                                 02294  49  03166  00000
12125         DORG  *-3                                02302
12135 RMFLL   CM    INPUT,14,10                        02302  14  00797  000J4
12145         BB    ,,0                                02314  M2  00000  00C0C
12155         DORG  *-9                                02316
12165 G15     TFM   SET,0,10                           02316  16  13313  000-0
12175         TF    INPUT-2,CLERER+9                   02328  26  00795  00741
12185         TF    INPUT+10,CLERER+11                 02340  26  00807  00743
12195         TF    INPUT+18,CLERER+7                  02352  26  00815  00739
12205         TFM   AA2+6,INPUT+20                     02364  16  02382  -0817
12215 AA2     TFM   ,,10                               02376  16  00000  000-0
12225         AM    AA2+6,2                            02388  11  02382  -0002
12235         CM    AA2+6,INPUT+140                    02400  14  02382  -0937
12245         BL    AA2                                02412  47  02376  01300
12255 TYPE    DS    2,*                                02423          2
12265         BB                                       02424  42  00000  00000
```

```
12275          DORG *-9                                  02426
12285 PASSI    BD   READ,PRSW                            02426  43  02634  08664
12295 PNCH1    WACD INPUT2-10                            02438  39  00949  00400
12305 G13      BT   RCTY,RCTY-1                          02450  27  08618  08617
12315          BE   READ,PRSW                            02462  43  02634  08664
12325 *
12335 *           READ STATEMENT FROM TYPEWRITER
12345 *
12355 A4       BT   RCTY1,RCTY1-1                        02474  27  08654  08653
12365          BT   G15,G15-1                            02486  27  02316  02315
12375          RATY INPUT-10                             02498  37  00787  00100
12385          BC4  A4                                   02510  46  02474  00400
12395 CNTR     DS   2,*                                  02521        2
12405 STAR     BT   RSCAN,RSCAN-1                        02522  27  01974  01973
12415          BNE  B4                                   02534  47  02566  01200
12425 A37      BD   READ,EJS                             02546  43  02634  00587
12435          B    PASSI                                02558  49  02426  00000
12445          DORG *-3                                  02566
12455 B4       BNR  UP,EJS                               02566  45  03002  00587
12465          B    H1                                   02578  49  02978  00000
12475          DORG *-3                                  02586
12485 *
12495 *           PUNCH LOADER
12505 *
12515 PLDR     TR   INPUT2,LODER1                        02586  31  00959  01296
12525          BT   A5,A5-1                              02598  27  06274  06273
12535          TR   INPUT2,LODER2                        02610  31  00959  01376
12545          BT   A5,A5-1                              02622  27  06274  06273
12555 *
12565 *           READ STATEMENT FROM CARD
12575 *
12585 READ     BT   G15,G15-1                            02634  27  02316  02315
12595          RACD INPUT-10                             02646  37  00787  00500
12605          BNR  STAR,EJS                             02658  45  02522  00587
12615          BT   RCTY,RCTY-1                          02670  27  08618  08617
12625          BT   RSCAN,RSCAN-1                        02682  27  01974  01973
12635 *
12645 *           CHECK FOR COMMENT STATEMENT
12655 *
12665 CASTER   BNE  NAST                                 02694  47  02774  01200
12675          BNF  B6,PRSW                              02706  44  02730  08664
12685          WATY INPUT-10                             02718  39  00787  00100
12695 B6       BTM  LINE,**12,7                          02730  17  06502  -2742
12705          TF   INPUT2+10,BLNKS-64                   02742  26  00969  15204
12715          BT   PCHCRD,PCHCRD-1                      02754  27  06262  06261
12725          B    READ                                 02766  49  02634  00000
12735          DORG *-3                                  02774
12745 *
12755 *           TYPE OUT SOURCE STATEMENT
12765 *
12775 NAST     BNF  G26,PRSW                             02774  44  02990  08664
12785          TF   LOPOUT,INPUT-2                       02786  26  01245  00795
12795          C    LOPOUT,CLEAER+9                      02798  24  01245  00741
12805          BNE  G16                                  02810  47  02878  01200
12815          TBTY                                      02822  34  00000  00108
12825 G19      TF   LOPOUT,INPUT+10                      02834  26  01245  00807
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12835          BD    G17,LOPOUT-11                    02846  43  02898  01234
12845          TBTY                                   02858  34  00000  00108
12855 ORDER    DC    4,1,*-4                          02865          4
               -001
12865          B     G18                              02870  49  02910  00000
12875          DCRG  *-3                              02878
12885 G16      WATY  LOPOUT-8                         02878  39  01237  00100
12895          B     G19                              02890  49  02834  00000
12905          DCRG  *-3                              02898
12915 G17      WATY  LOPOUT-10                        02898  39  01235  00100
12925 G18      TF    LOPOUT,INPUT+16                  02910  26  01245  00815
12935          WATY  LOPOUT-6                         02922  39  01239  00100
12945          BNR   B8,INPUT+20                      02934  45  02954  00817
12955          B     A49                              02946  49  02966  00000
12965          DCRG  *-3                              02954
12975 B8       WATY  INPUT+20                         02954  39  00817  00100
12985 A49      BNF   G26,PRSW                         02966  44  02990  08664
12995 B1       TBTY                                   02978  34  00000  00108
13005 PICKUP   DS    5,*-5                            02984          5
13015 G26      BC    A6,SET                           02990  43  03166  13313
13025 *
13035 *          SCAN OPCODE TABLE
13045 *
13055 CP       CM    INPUT+12,7C,10                   03002  14  00809  000P0
13065          BL    ALFOP                            03014  47  03070  01300
13075          TD    ZERO+28,INPUT+12                 03026  25  00528  00809
13085          TD    ZERO+29,INPUT+14                 03038  25  00529  00811
13095          TCM   GOODB+11,-2                      03050  15  03353  0000K
13105          B     INST                             03062  49  08764  00000
13115          DCRG  *-3                              03070
13125 ALFOP    TFM   B10+11,A-11                      03070  16  03105  J5431
13135          AM    B10+11,11,10                     03082  11  03105  000J1
13145 B10      TF    ZERO+30                          03094  26  00530  00000
13155 COMP     C     ZERO+27,INPUT+16                 03106  24  00527  00815
13165          BE    OK                               03118  46  03318  01200
13175          CM    COMP-1,XDEND                     03130  14  03105  J6817
13185          BL    COMP-24                          03142  47  03082  01300
13195 ER3      TFM   EVALER-1,3C000                   03154  16  05105  L0000
13205          DC    1,*,*                            03165          1
               *
13215 A6       BT    EPRINT,EPRINT-1                  03166  27  05310  05309
13225          BC2   A7                               03178  46  05142  00200
13235          PT    JUST,JUST-1                      03190  27  08944  08943
13245          AM    ADDCOM,11,10                     03202  11  00725  000J1
13255 *
13265 *          STATEMENT HAD RECORD MARK IN LABEL OR OPCODE FIELD
13275 *          OR THE OPCODE WAS INVALID, HENCE IT IS TREATED AS A NOP
13285 *
13295          CM    KLOP+11,INPUT+10                 03214  14  02233  -0807
13305          BL    G24,EJS                          03226  43  03258  00587
13315          BH    LDLOL                            03238  46  14194  01100
13325          B     PASSI                            03250  49  02426  00000
13335          DCRG  *-3                              03258
13345 G24      TR    ZERO,NUPREC-12                   03258  31  00500  00708
13355          TLM   GOODB+11,-2                      03270  15  03353  0000K
13365          BNF   LINPRT,PRSW                      03282  44  06342  08664
```

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13375          BI    RCTY,RCTY-1                          03294  27  08618  08617
13385          BTM   TABBY1,LINPRT,7                      03306  17  08524  -6342
13395 *
13405 *           USING THE LAST DIGIT OF THE OPCODE ENTRY GOODB IS
13415 *           MODIFIED TO BRANCH TO THE CORRECT ENTRY IN BTBL
13425 *
13435 OK       TFM   GOOD1+11,BTBL                        03318  16  03377  -3424
13445          TD    GOODB+11,ZERO+30                     03330  25  03353  00530
13455 GOODB    MM    *+9,500,81C                          03342  13  03351  0-5-0
13465          A     GOOD1+11,99                          03354  21  03377  00099
13475 GOOD1    TF    GOOD2+6                              03366  26  03384  00000
13485 GOOD2    B                                          03378  49  00000  00000
13495          DORG  *-4                                  03385
13505          DSA   MACRO                                03389          5 X    1

                                                          03389       -9670
13515          DSA   TRA,INST,BI,BNI                      03394          5 X    4

                                                          03394       J4146
                                                          03399       -8764
                                                          03404       -6776
                                                          03409       -8788
13525          DSA   ROW,K                                03414          5 X    2

                                                          03414       -8800
                                                          03419       -8812
13535 BTBL     DSA   DSDNB,DAS,DC,DAC,DSA                 03424          5 X    5

                                                          03424       J1024
                                                          03429       -9974
                                                          03434       J2710
                                                          03439       J0124
                                                          03444       J3614
13545          DSA   DSB,DORG,DEND,HEADER,MORG            03449          5 X    5

                                                          03449       J0764
                                                          03454       J1304
                                                          03459       J1444
                                                          03464       -5470
                                                          03469       J1212
13555 *
13565 *           THE FOLLOWING CLOSED SUBROUTINE EVALUATES
13575 *           THE STATEMENT OPERAND
13585 *
13595          NOP                                        03470  41  00000  00000
13605 EVALAD   TF    ADDRS,CLERER+9                       03482  26  01122  00741
13615          TFM   EVALAD-9,100,9                       03494  16  03473  00J00
13625          TF    BETA,ONEZ                            03506  26  12413  00699
13635          TFM   ALPHA,0                              03518  16  00411  -0000
13645          SF    HED-2                                03530  32  14339  00000
13655          SF    EVALAD-5                             03542  32  03477  00000
13665          TDM   ADRS+1,1                             03554  15  04011  00001
13675          TDM   RETURN+1,9                           03566  15  04059  00009
13685          TR    COLL-18,THINGS-20                    03578  31  00600  00621
13695          TFM   LADL,1,10                            03590  16  03825  000-1
13705          TFM   DDL,,10                              03602  16  03823  000-0
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13715          BNF  BCMSPC,EVALAD-7                    03614 44 03874 03475
13725 A12      TR   COLL-18,THINGS-20                  03626 31 00600 00621
13735          TFM  LABL,1,10                          03638 16 03825 000-1
13745          TFM  DOL,,10                            03650 16 03823 000-0
13755          B    A11                                03662 49 03862 00000
13765          DORG *-3                                03670
13775 *           CHECK FOR COMMA
13785 S1       CM   INPUT+20,23,10                     03670 14 00817 000K3
13795          BE   COMMER                             03682 46 03886 01200
13805 *           CHECK FOR ASTERISK
13815          CM   INPUT+20,14,10                     03694 14 00817 000J4
13825          BE   ASTER                              03706 46 04686 01200
13835 *           CHECK FOR DOLLAR SIGN
13845          CM   INPUT+20,13,10                     03718 14 00817 000J3
13855          BE   DOLLAR                             03730 46 04150 01200
13865          TDM  LABL                               03742 15 03825 00000
13875 A13      CM   COLL-17,7,10                       03754 14 00601 000-7
13885          BNE  B13                                03766 47 03802 01200
13895 *           SYMBOL IN OPERAND CONTAINS MORE THAN SIX CHARACTERS,
13905 *           NUMBER IN OPERAND HAS MORE THAN FIVE DIGITS OR
13915 *           UNDEFINED SYMBOL IN OPERAND
13925 ER5      TDM  SET2,                              03778 15 13312 00000
13935          DC   1,',',*                            03789      1
               *
13945          BTM  EVALER,50000                       03790 17 05106 N0000
13955          DC   1,',',*                            03801      1
               *
13965 B13      TF   COLL,INPUT+20                      03802 26 00618 00817
13975          CF   COLL-1                             03814 33 00617 00000
13985 LABL     DS   ,*                                 03825      0
13995 DOL      DS   ,*-2                               03823      0
14005          AM   DOL,1,10                           03826 11 03823 000-1
14015          TDM  EVALAD-11                          03838 15 03471 00000
14025 A14      TK   COLL-17,COLL-15                    03850 31 00601 00603
14035 A11      TK   INPUT+19,INPUT+21                  03862 31 00816 00818
14045 *           CHECK TO SEE IF OPERAND IS PRESENT
14055 BCMSPC   BNR  COMSPC,INPUT+20                    03874 45 03906 00817
14065 COMMER   TDM  RETURN+1,1                         03886 15 04059 00001
14075          B    GET1                               03898 49 03974 00000
14085          DORG *-3                                03906
14095 *           CHECK FOR SPECIAL CHARACTER
14105 COMSPC   CM   INPUT+20,7C,10                     03906 14 00817 000P0
14115          BNL  A13                                03918 46 03754 01300
14125 *           CHECK FOR + OR -
14135 SPEC     BC   S1,INPUT+20                        03930 43 03670 00817
14145 *           CHECK FOR BLANK
14155          BC   B14,INPUT+19                       03942 43 03962 00816
14165          B    A11                                03954 49 03862 00000
14175          DORG *-3                                03962
14185 B14      TC   B15+11,INPUT+19                    03962 25 04033 00816
14195 GET1     BC   ADRS,EVALAD-11                     03974 43 04010 03471
14205          BT   GET,*+12,7                         03986 27 04294 -3998
14215          BT   MULT,MULT-1                        03998 27 04600 04599
14225 ADRS     A    ADDRS,ALPHA,0                      0401C K1 01122 J0411
14235 B15      TDM  ADRS+1,1                           04022 15 04011 00001
14245          TFM  EVALAD-9,100,9                     04034 16 03473 00J00
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14255          TF    BETA,ONEZ                                  04046  26  12413  00699
14265 RETURN   B     A12                                        04058  49  03626  00000
14275          C     ADDRS-5,CLERER+4                           04070  24  01117  00736
14285          BNH   E16                                        04082  47  04118  01100
14295 *          ASSEMBLED OPERAND IS GREATER THAN FIVE DIGITS
14305 ER11     TDM   SET2,                                      04094  15  13312  00000
14315          DC    1,',*                                      04105          1
                     '
14325          BTM   EVALER,1710                                04106  17  05106  J7100
14335          DC    1,',*                                      04117          1
                     '
14345 B16      SF    ADDRS-4                                    04118  32  01118  00000
14355 TOBB     TF    BBACK+6,EVALAD-1                           04130  26  04148  03481
14365 BBACK    B     ,,2                                        04142  49  -0000  00000
14375          DORG  *-3                                        04150
14385 DOLLAR   BC    B17,DOL                                    04150  43  04182  03823
14395          TFM   COLL,,10                                   04162  16  00618  000-0
14405          B     B18                                        04174  49  04218  00000
14415          DORG  *-3                                        04182
14425 B17      CM    DOL,1,10                                   04182  14  03823  000-1
14435          BNE   LRCHAR                                     04194  47  04274  01200
14445          SF    COLL-3                                     04206  32  00615  00000
14455 B18      CF    HED-2                                      04218  33  14339  00000
14465          TDM   EVALAD-11,1                                04230  15  03471  00001
14475          TDM   LABL                                       04242  15  03825  00000
14485          BC    A11,DOL                                    04254  43  03862  03823
14495          B     A14                                        04266  49  03850  00000
14505          DORG  *-3                                        04274
14515 *          DOLLAR SIGN IMPROPERLY PLACED
14525 ERCHAR   BTM   EVALER,40000                                04274  17  05106  M0000
14535          DC    1,',*                                      04285          1
                     '
14545 G4       B                                                04286  49  00000  00000
14555          DORG  *-3                                        04294
14565 GET      BC    TRNUMB,LABL                                04294  43  04442  03825
14575          BNE   LBADD,HED-2                                04306  44  04830  14339
14585          CM    COLL-14,06070                              04318  14  00604  -6070
14595          BNE   B19                                        04330  47  04374  01200
14605          SF    COLL-2                                     04342  32  00616  00000
14615 TBLEND   DS    5,*                                        04353          5
14625          SF    COLL-13                                    04354  32  00605  00000
14635          B     LBADD                                      04366  49  04830  00000
14645          DORG  *-3                                        04374
14655 B19      TFM   B20+6,COLL-2                               04374  16  04416  -0616
14665          S     B20+6,COLL-17                              04386  22  04416  00601
14675          S     B20+6,COLL-17                              04398  22  04416  00601
14685 B20      TF    ,HED                                       04410  26  00000  14341
14695          AM    COLL-17,1,10                               04422  11  00601  000-1
14705          B     LBADD                                      04434  49  04830  00000
14715          DORG  *-3                                        04442
14725 TRNUMB   CM    COLL-14,6060                               04442  14  00604  -6060
14735          BH    ER5                                        04454  46  03778  01100
14745          TDM   NUMb-1,,11                                 04466  15  00647  0000-
14755          TFM   TRNUM1+11,COLL-2                           04478  16  04537  -0616
14765          S     TRNUM1+11,COLL-17                          04490  22  04537  00601
14775          S     TRNUM1+11,COLL-17                          04502  22  04537  00601
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14785 A15     TR    NUMB-5,NUMB-4
14795 TRNUM1  TD    NUMB-1
14805         TR    COLL-17,COLL-15
14815         TF    B21+11,TRNUM1+11
14825 B21     BNR   A15
14835         TFM   ALPHA
14845         A     ALPHA,NUMB-1
14855         BB    ,,0
14865         DORG  *-9
14875 MULT    M     ALPHA,BETA
14885         C     89,CLERER+9
14895         BE    B22
14905 *          MULTIPLICATION HAS BEEN USED IN ADDRESS ARITHMETIC
14915 *          AND THE PRODUCT IS GREATER THAN TEN DIGITS
14925         BTM   EVALER,20000
14935         DC    1,',*
              *
14945 B22     SF    90
14955         TF    ALPHA,99
14965         TF    BETA,99
14975         BB    ,,0
14985         DORG  *-9
14995 ASTER   BC    TEST3,EVALAD-11
15005         BT    GET,*+12,7
15015         BT    MULT,MULT-1
15025         TFM   EVALAD-10,11,10
15035         B     A12
15045         DORG  *-3
15055 TEST3   BC    TFADD,EVALAD-10
15065         BD    SW2,EVALAD-9
15075 TFADD   TF    ALPHA,ADDCOM
15085         BT    MULT,MULT-1
15095         TFM   EVALAD-9,1,10
15105         B     A12
15115         DORG  *-3
15125 SW2     TCM   EVALAD-9
15135         B     A12
15145         DORG  *-3
15155 LBACD   TF    LABCTR,COLL-17
15165         TF    INPUT3,COLL-2
15175         TFM   D33+6,ER5,7
15185         BT    IT,IT-1
15195 LABOK   TF    B38+11,D26+11
15205         AM    B38+11,5,10
15215 B38     TF    ALPHA
15225         B     G4
15235         DORG  *-3
15245 *
15255 *          THE SYMBOL TABLE IS SEARCHED FOR EQUIVALENCE
15265 *
15275 IT      TFM   A63+11,SYMTBL
15285 A63     BC    SEIFIN
15295 D33     B
15305         DORG  *-3
15315 SEIFIN  TF    D24+11,A63+11
15325 D24     TC    D25+11
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04514  31  00643  00644
04526  25  00647  00000
04538  31  00601  00603
04550  26  04573  04537
04562  45  04514  00000
04574  16  00411  -0000
04586  21  00411  00647
04598  M2  00000  00000
04600
04600  23  00411  12413
04612  24  00089  00741
04624  46  04648  01200

04636  17  05106  K0000
04647          1

04648  32  00090  00000
04660  26  00411  00099
04672  26  12413  00099
04684  M2  00000  00C00
04686
04686  43  04742  03471
04698  27  04294  -4710
04710  27  04600  04599
04722  16  03472  000J1
04734  49  03626  00000
04742
04742  43  04766  03472
04754  43  04810  03473
04766  26  00411  00725
04778  27  04600  04599
04790  16  03473  0C0-1
04802  49  03626  00000
04810
04810  15  03473  00000
04822  49  03626  00000
04830
04830  26  14217  00601
04842  26  01585  00616
04854  16  04952  -3778
04866  27  04922  04921
04878  26  04913  05049
04890  11  04913  000-5
04902  26  00411  00000
04914  49  04286  00000
04922

04922  16  04945  J6818
04934  43  04954  00000
04946  49  00000  00000
04954
04954  26  04977  04945
04966  25  05001  00000
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15335          TF    D26+11,D24+11                    04978 26 05049 04977
15345 D25      AM    D26+11,,10                       04990 11 05049 00C-0
15355          A     D26+11,D25+11                    05002 21 05049 05C01
15365 D28      C     CARCTR,D25+11                    05014 24 14217 05001
15375          BNE   D27                              05026 47 05062 01200
15385 D26      C     INPUT3                           05038 24 01585 00000
15395 D29      BE    BB                               05050 46 06334 01200
15405 D27      TF    A63+11,D26+11                    05062 26 04945 05049
15415          AM    A63+11,6,10                      05074 11 04945 000-6
15425          B     A63                              05086 49 04934 00000
15435          DORG  *-3                              05C94
15445          BNR   59007                            05094 45 59007 00000
15455 *
15465 *          EVALER IS THE ERROR ROUTINE
15475 *
15485 EVALER   BT    EPRINT,EPRINT-1                  05106 27 05310 05309
15495          BC    EV1,EJS                          05118 43 05174 00587
15505          BNC2  CHKND                            05130 47 05222 00200
15515 A7       TF    ADDCOM,PLACE                     05142 26 00725 06365
15525          SM    INKRM,1,10                       05154 12 15082 000-1
15535          B     A4                               05166 49 02474 00000
15545          DORG  *-3                              05174
15555 EV1      BC2   A7                               05174 46 05142 00200
15565          BNF   CHKND,PRSW                       05186 44 05222 08664
15575          BT    RCTY,RCTY-1                      05198 27 08618 08617
15585          BTM   TABBY1,**12,7                    05210 17 08524 -5222
15595 CHKND    TFM   ADDRS                            05222 16 01122 -0000
15605          BC    TOBB,SET2                        05234 43 04130 13312
15615 B24      BNR   B23,INPUT+20                     05246 45 05266 00817
15625          B     TOBB                             05258 49 04130 00000
15635          DORG  *-3                              05266
15645 B23      CM    INPUT+20,23,10                   05266 14 00817 000K3
15655          BE    TOBB                             05278 46 04130 01200
15665          TR    INPUT+19,INPUT+21                05290 31 00816 00818
15675          B     B24,,2                           05302 49 -5246 00000
15685          DORG  *-3                              05310
15695 *
15705 *          EPRINT PRINTS THE ERROR MESSAGE AND REFERENCE TO
15715 *          INDICATE THE STATEMENT IN ERROR
15725 *
15735 EPRINT   BNF   B25,PRSW                         05310 44 05334 08664
15745          BC    B26,EJS                          05322 43 05382 00587
15755 B25      RCTY                                   05334 34 00000 00102
15765          WATY  ERLAB                            05346 39 01155 00100
15775          WNTY  INKRM-3                          05358 38 15079 00100
15785          TBTY                                   05370 34 00000 00108
15795 B26      WATY  EVALER-11                        05382 39 05095 00100
15805          BB                                     05394 42 00000 00000
15815          DORG  *-3                              05402
15825 WRPRND   C     INPUT2+73,FINAL                  05402 24 01032 15431
15835          BNE   B27                              05414 47 05438 01200
15845          TDM   INPUT2+69,,11                    05426 15 01028 0000-
15855 B27      BNC3  PCHCRD                           05438 47 06262 00300
15865          TF    B28+6,WRPRND-1                   05450 26 05468 05401
15875 B28      B                                      05462 49 00000 00000
15885          DORG  *-3                              05470
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15895 *
15905 *          HEADER ROUTINE
15915 *
15925 HEADER TFM   HED,,10                                  05470  16  14341  000-0
15935        TCM   HEADER-1                                 05482  15  05469  00000
15945 A10    BNR   COMA,INPUT+20                            05494  45  05550  00817
15955 A9     BNR   PASSI,EJS                                05506  45  02426  00587
15965 A8     BTM   LINE,*+12                                05518  17  06502  -5530
15975        BT    PCHCRD,PCHCRD-1                          05530  27  06262  06261
15985        B     READ                                     05542  49  02634  00000
15995        DORG  *-3                                      05550
16005 COMA   CM    INPUT+20,23,10                           05550  14  00817  000K3
16015        BE    A9                                       05562  46  05506  01200
16025 *          HEADER OPERAND GREATER THAN ONE CHARACTER
16035        BC    ER13,HEADER-1                            05574  43  05710  05469
16045        CM    INPUT+20,,10                             05586  14  00817  000-0
16055        BE    B12                                      05598  46  05658  01200
16065        CM    INPUT+20,40,10                           05610  14  00817  000M0
16075 *          SPECIAL CHARACTER USED AS HEADER
16085        BL    ER12                                     05622  47  05678  01300
16095        TF    HED,INPUT+20                             05634  26  14341  00817
16105        TDM   HEADER-1,1                               05646  15  05469  00001
16115 B12    TR    INPUT+19,INPUT+21                        05658  31  00816  00818
16125        B     A10                                      05670  49  05494  00000
16135        DORG  *-3                                      05678
16145 ER12   TFM   EVALER-1,17200                           05678  16  05105  J7200
16155        DC    1,',*                                    05689          1
                   '
16165        TFM   HED,,10                                  05690  16  14341  000-0
16175        B     A64                                      05702  49  05722  00000
16185        DORG  *-3                                      05710
16195 ER13   TFM   EVALER-1,17300                           05710  16  05105  J7300
16205        DC    1,',*                                    05721          1
                   '
16215 A64    BT    EPRINT,EPRINT-1                          05722  27  05310  05309
16225        BC2   A7                                       05734  46  05142  00200
16235        B     A9                                       05746  49  05506  00000
16245        DORG  *-3                                      05754
16255 *
16265 *          THE FOLLOWING ROUTINE PROVIDES A CONDENSED OBJECT DECK IF
16275 *          ONE IS DESIRED
16285 *
16295 CMPCON TLM   CONCD+11,1                               05754  15  05921  00001
16305 A19    TF    TEST,INPUT2+73                           05766  26  08530  01032
16315        S     TEST,INPUT2+68                           05778  22  08530  01027
16325        CM    SIXTY,60,10                              05790  14  13337  00000
16335        BNE   A16                                      05802  47  06142  01200
16345 EMPTY  TF    TYPE,INPUT2+63                           05814  26  02423  01022
16355        TF    CMPOUT+68,INPUT2+68                      05826  26  01562  01027
16365 A18    TFM   TR+11,INPUT2-1                           05838  16  05873  -0958
16375        A     TR+11,INPUT2+63                          05850  21  05873  01022
16385 TR     TR    CMPOUT,0,2                               05862  31  -1494  00000
16395        A     TR+6,TEST                                05874  21  05868  08530
16405        TF    CMPOUT+73,INPUT2+73                      05886  26  01567  01032
16415        TF    TESTAD,INPUT2+73                         05898  26  13217  01032
16425 CONCD  TDM   CMPOUT+61,1                              05910  15  01555  00001
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16435          TF    B29+11,TR+11                    05922  26  05969  05873
16445          A     B29+11,TEST                     05934  21  05969  08530
16455          SM    B29+11,1                        05946  12  05969  -0001
16465 B29      BNR   B30                             05958  45  05978  00000
16475          B     A17                             05970  49  06002  00000
16485          DORG  *-3                             05978
16495 B30      S     SIXTY,TEST                      05978  22  13337  08530
16505          BNZ   B8                              05990  47  06334  01200
16515 A17      TCM   BRRDBB+1,2                      06002  15  06135  00002
16525 PUNCHY   TFM   CMPOUT+63,1,10                  06014  16  01557  000-1
16535          BNC4  B31                             06026  47  06098  00400
16545          AM    ORDER,1                         06038  11  02865  -0001
16555          TF    CMPOUT+79,ORDER                 06050  26  01573  02865
16565          CF    CMPOUT+76                       06062  33  01570  00000
16575          TCM   CMPOUT+75,0,11                  06074  15  01569  0000-
16585          WNCD  CMPOUT                          06086  38  01494  00400
16595 B31      TFM   SIXTY,60                        06098  16  13337  -0060
16605          TF    CMPOUT+74,BLNKS                 06110  26  01568  15268
16615          TFM   TR+6,CMPOUT                     06122  16  05868  -1494
16625 BRRDBB   B     EMPTY                           06134  49  05814  00000
16635          DORG  *-3                             06142
16645 A16      C     INPUT2+63,TYPE                  06142  24  01022  02423
16655          BE    B32                             06154  46  06186  01200
16665 B33      TCM   BRRDBB+1,9                      06166  15  06135  00009
16675          B     PUNCHY                          06178  49  06014  00000
16685          DORG  *-3                             06186
16695 B32      C     TESTAD,INPUT2+68                06186  24  13217  01027
16705          BNE   B33                             06198  47  06166  01200
16715          C     SIXTY,TEST                      06210  24  13337  08530
16725          BL    B33                             06222  47  06166  01300
16735          B     A18                             06234  49  05838  00000
16745          DORG  *-3                             06242
16755 CMPINS   TCM   CONCD+11,0                      06242  15  05921  00000
16765          B     A19,,2                          06254  49  -5766  00000
16775          DORG  *-3                             06262
16785 *
16795 *          PCHCRD PUNCHES A CARD NUMERICALLY
16805 *
16815 PCHCRD   BC3   B8                              06262  46  06334  00300
16825 A5       BNC4  B8                              06274  47  06334  00400
16835          AM    ORDER,1                         06286  11  02865  -0001
16845          TF    INPUT2+79,ORDER                 06298  26  01038  02865
16855          CF    INPUT2+76                       06310  33  01035  00000
16865          WNCD  INPUT2                          06322  38  00959  00400
16875 B8       B8                                    06334  42  00000  00000
16885          DORG  *-3                             06342
16895 *
16905 *          THE ROUTINE WHICH FOLLOWS TAKES CARE OF THE
16915 *          OUTPUT FOR THE PROCESSOR
16925 *
16935 LINPRT   CF    ADDRS-4                         06342  33  01118  00000
16945          CF    LNTH-4                          06354  33  00700  00000
16955 PLACE    DS    5,*                             06365        5
16965          CF    TEMPR-4                         06366  33  00726  00000
16975          BTM   LINE,*+12                       06378  17  06502  -6190
16985          TR    INPUT2+12,LNTH-4                06390  31  00971  00700
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16995          TD    INPUT2+17,BLNKS                          06402  25  00976  15268
17005 *
17015 *          IF A TYPED LISTING IS TO BE MADE, TYPE ADDRESS
17025 *
17035          BNF   PRT1,PRSW                                06414  44  06438  08664
17045          BT    SPAT,SPAT-1                              06426  27  08592  08591
17055 PRT1     BNF   PRT2,GOODB+11                            06438  44  06458  03353
17065          B     DOINST                                   06450  49  07956  00000
17075          DORG  *-3                                      06458
17085 PRT2     TF    BRNCH+6,LINPRT-1                         06458  26  06500  06341
17095          BNF   BRNCH,PRSW                               06470  44  06494  08664
17105 *
17115 *          IF A DECLARATIVE, ALSO TYPE LENGTH
17125 *
17135          WNTY LNTH-4                                    06482  38  00700  00100
17145 BRNCH    B                                              06494  49  00000  00000
17155          DORG  *-3                                      06502
17165 *
17175 *          PUNCH SOURCE STATEMENT AND PREPARE FOLLOWING CARD
17185 *
17195 LINE     BT     PCHALF,PCHALF-1                         06502  27  07190  07189
17205          TD    INPUT2+4,INPUT-2                         06514  25  00963  00795
17215          TD    INPUT2+3,INPUT-4                         06526  25  00962  00793
17225          TD    INPUT2+2,INPUT-6                         06538  25  00961  00791
17235          TD    INPUT2+1,PCHALF+7                        06550  25  00960  07197
17245          TDM   INPUT2,9                                 06562  15  00959  00009
17255 G22      TF    INPUT2+79,BLNKS                          06574  26  01038  15268
17265          TR    INPUT2+5,ADDRS-4                         06586  31  00964  01118
17275          TD    INPUT2+10,BLNKS                          06598  25  00969  15268
17285          TDM   INPUT2+75,9                              06610  15  01034  00009
17295          TF    B39+6,LINE-1                             06622  26  06640  06501
17305 B39      B                                              06634  49  00000  00000
17315          DORG  *-3                                      06642
17325 CODSB    BNF   DODS,PRSW                                06642  44  06678  08664
17335 *
17345 *          IF DSB TYPE NUMBER OF ELEMENTS
17355 *
17365          SPTY                                           06654  34  00000  00101
17375          WNTY TEMPR-4                                   06666  38  00726  00100
17385 DODS     C     INPUT+18,XDSB-3                          06678  24  00815  16539
17395          BNE   B40                                      06690  47  06714  01200
17405          TR    INPUT2+17,TEMPR-4                        06702  31  00976  00726
17415 B40      BT    PCHCRD,PCHCRD-1                          06714  27  06262  06261
17425          C     INPUT+18,XDNB-3                          06726  24  00815  16550
17435          BNE   LDLBL                                    06738  47  14194  01200
17445 *
17455 *          GENERATE OUTPUT CARDS FOR NUMERIC BLANK
17465 *
17475          TF    INPUT2-2,INPUT-2                         06750  26  00957  00795
17485          TR    INPUT2-1,CLERER                          06762  31  00958  00732
17495          TR    INPUT2+52,CLERER                         06774  31  01011  00732
17505          TF    INPUT2+112,CLERER+50                     06786  26  01071  00782
17515          TFM   BLKVR+11,INPUT2+2                        06798  16  06881  -0961
17525          A     BLKVR+11,LNTH                            06810  21  06881  00704
17535          A     BLKVR+11,LNTH                            06822  21  06881  00704
17545          TFM   B41+6,INPUT2+2                           06834  16  06852  -0961
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17555 B41    TFM  ,34,10                                  06846 16 00000 000L4
17565        AM   B41+6,2                                 06856 11 06852 -0002
17575 BLKVR  CM   B41+6                                   06870 14 06852 -0000
17585        BNE  B41                                     06882 47 06846 01200
17595        TF   B42+6,BLKVR+11                          06894 26 06912 06881
17605 B42    TFM  ,,10                                    06906 16 00000 000-0
17615        DC   1,',*
                                                          06917     1
17625        TR   INPUT2+113,BLSND-1                      06918 31 01072 01456
17635        SF   ADDRS-4                                 06930 32 01118 00000
17645        AM   ADDRS,1                                 06942 11 01122 -0001
17655        TD   INPUT2+128,ADDRS-4                      06954 25 01087 01118
17665        TD   INPUT2+130,ADDRS-3                      06966 25 01089 01119
17675        TD   INPUT2+132,ADDRS-2                      06978 25 01091 01120
17685        TD   INPUT2+134,ADDRS-1                      06990 25 01093 01121
17695        TD   INPUT2+136,ADDRS                        07002 25 01095 01122
17705        TD   *+19,ADDRS-4                            07014 25 07033 01118
17715        CM   FINAL                                   07026 14 15431 -0000
17725        BNE  *+24                                    07038 47 07062 01200
17735        TDM  INPUT2+128,,11                          07050 15 01087 0000-
17745        S    ADDRS,LNTH                              07062 22 01122 00704
17755        TD   INPUT2+118,ADDRS-4                      07074 25 01077 01118
17765        TD   INPUT2+120,ADDRS-3                      07086 25 01079 01119
17775        TD   INPUT2+122,ADDRS-2                      07098 25 01081 01120
17785        TD   INPUT2+124,ADDRS-1                      07110 25 01083 01121
17795        TD   INPUT2+126,ADDRS                        07122 25 01085 01122
17805        BT   B891,B891-1                             07134 27 11592 11591
17815        BT   A21,A21-1                               07146 27 07250 07249
17825        SM   ADDRS,1                                 07158 12 01122 -0001
17835        A    ADDRS,LNTH                              07170 21 01122 00704
17845        B    LOLBL,,2                                07182 49 34194 00000
17855        DCRG *-3                                     07190
17865 *
17875 *          PCHALF ROUTINE PUNCHES A CARD ALPHABETICALLY
17885 *
17895 PCHALF BC3  BB                                      07190 46 06334 00300
17905        BNC4 BB                                      07202 47 06334 00400
17915        TD   PCHALF+7,INPUT-10                       07214 25 07197 00787
17925        TFM  INPUT2-10,76,10                         07226 16 00949 000P6
17935        TFM  INPUT2+140,70,10                        07238 16 01099 000P0
17945 A21    BNC4 BB                                      07250 47 06334 00400
17955        AM   ORDER,1,10                              07262 11 02865 000-1
17965        TF   INPUT2+147,SEVENS                       07274 26 01106 11905
17975        TD   INPUT2+148,ORDER                        07286 25 01107 02865
17985        TD   INPUT2+142,ORDER-3                      07298 25 01101 02862
17995        TD   INPUT2+144,ORDER-2                      07310 25 01103 02863
18005        TD   INPUT2+146,ORDER-1                      07322 25 01105 02864
18015        WACD INPUT2-10                               07334 39 00949 00400
18025        TFM  INPUT2-10,00,10                         07346 16 00949 000-0
18035        BB                                           07358 42 00000 00000
18045        DCRG *-9                                     07360
18055 *
18065 *          THE FOLLOWING ROUTINE HANDLES THE TYPED OUTPUT FOR DSA
18075 *
18085 TYPDSA BNF  PCON,PRSW                               07360 44 07520 08664
18095        TFM  B45+11,ZERO                             07372 16 07419 -0500
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18105 A22     WATY CLERER+45                    07384  39  00777  00100
18115         AM   B45+11,5                     07396  11  07419  -0005
18125 B45     TF   TYPADD-1                     07408  26  08610  00000
18135         WNTY TYPADD-5                     07420  38  08606  00100
18145         TF   B47+11,B45+11                07432  26  07467  07419
18155         AM   B47+11,1,10                  07444  11  07467  000-1
18165 B47     BNR  B46                          07456  45  07476  00000
18175         B    PCON                         07468  49  07520  00000
18185         DORG *-3                          07476
18195 B46     BT   RCTY,RCTY-1                  07476  27  08618  08617
18205         BTM  TABBY1,G5,7                  07488  17  08524  -8580
18215         WNTY LNTH-4                       07500  38  00700  00100
18225         B    A22                          07512  49  07384  00000
18235         DORG *-3                          07520
18245 *
18255 *          PUNCH THE CONSTANT CARDS
18265 *
18275 PCON    C    INPUT+18,XDSA-3              07520  24  00815  16528
18285         BT   PDSA                         07532  46  07840  01200
18295         BT   PCHCRD,PCHCRD-1              07544  27  06262  06261
18305         TF   INPUT2+74,BLNKS              07556  26  01033  15268
18315         TR   INPUT2+62,CONSND-11          07568  31  01021  15269
18325         TFM  PCON1+6,OUT+2                07580  16  07622  -0420
18335         A    PCON1+6,INPUT2+73            07592  21  07622  01032
18345         S    PCON1+6,INPUT2+68            07604  22  07622  01027
18355 PCON1   TC   ,RECMK                       07616  25  00000  01796
18365         SM   PCON1+6,OUT+2                07628  12  07622  -0420
18375         CM   PCON1+6,51                   07640  14  07622  -0051
18385         BN   A23                          07652  47  07808  01300
18395         TD   PCON2+11,OUT+52              07664  25  07759  00470
18405         TC   OUT+52,RECMK                 07676  25  00470  01796
18415         TR   INPUT2+5,OUT+2               07688  31  00964  00420
18425         TF   PCON3+11,INPUT2+73           07700  26  07807  01032
18435         TF   INPUT2+73,INPUT2+68          07712  26  01032  01027
18445         AM   INPUT2+73,50                 07724  11  01032  -0050
18455         BTM  WRPRND,CMPCON                07736  17  05402  -5754
18465 PCON2   TEM  OUT+2                        07748  15  00420  00C00
18475         TR   OUT+3,OUT+53                 07760  31  00421  00471
18485         TF   INPUT2+68,INPUT2+73          07772  26  01027  01032
18495         TF   INPUT2+61,BLNKS-18           07784  26  01020  15250
18505 PCON3   TFM  INPUT2+73                    07796  16  01032  -0000
18515 A23     TR   INPUT2+5,OUT+2               07808  31  00964  00420
18525         BTM  WRPRND,CMPCON                07820  17  05402  -5754
18535         B    LDLBL                        07832  49  14194  00000
18545         DORG *-3                          07840
18555 PDSA    TR   INPUT2+62,DSASND-11          07840  31  01021  15288
18565 A24     AM   INPUT2+73,5                  07852  11  01032  -0005
18575         AM   INPUT2+68,5                  07864  11  01027  -0005
18585         TF   INPUT2+21,ZEPO+5             07876  26  00980  00505
18595         TC   INPUT2+22,RECMK              07888  25  00981  01796
18605         BTM  WRPRND,CMPCON                07900  17  05402  -5754
18615         AM   INPUT2+9,5                   07912  11  00968  -0005
18625         TR   ZEPO+1,ZEPO+6                07924  31  00501  00506
18635         BNR  A24,ZEPO+1                   07936  45  07852  00501
18645         B    LDLBL                        07948  49  14194  00000
18655         DORG *-3                          07956
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18665 *
18675 *          OUTPUT ROUTINE FOR INSTRUCTIONS AND LINKAGES
18685 *
18695 OOINST TR   INPUT2+62,INSND-11                    07956 31 01021 15307
18705        SF   ADDRS-4                               07968 32 01118 00000
18715        TF   INPUT2+73,ADDRS                       07980 26 01032 01122
18725        TF   INPUT2+68,ADDRS                       07992 26 01027 01122
18735        AM   INPUT2+73,12                          08004 11 01032 -0012
18745 A26    CF   ADDRS-4                               08016 33 01118 00000
18755        BNF  NOTYPE,PRSW                           08028 44 08172 08664
18765        TR   OUT,ZERO                              08040 31 00418 00500
18775        TR   OUT+3,ZERO+2                          08052 31 00421 00502
18785        TR   OUT+9,ZERO+7                          08064 31 00427 00507
18795        TD   OUT+2,RECMK                           08076 25 00420 01796
18805        TD   OUT+8,RECMK                           08088 25 00426 01796
18815        TD   OUT+14,RECMK                          08100 25 00432 01796
18825        WNTY OUT                                   08112 38 00418 00100
18835        SPTY                                       08124 34 00000 00101
18845        WNTY OUT+3                                 08136 38 00421 00100
18855        SPTY                                       08148 34 00000 00101
18865        WNTY OUT+9                                 08160 38 00427 00100
18875 NOTYPE TD   401,ZERO+12                           08172 25 00401 00512
18885        TD   ZERO+12,RECMK                         08184 25 00512 01796
18895        TR   INPUT2+10,ZERO                        08196 31 00969 00500
18905        TD   ZERO+12,401                           08208 25 00512 00401
18915        BTM  WRPRND,CMPINS                         08220 17 05402 -6242
18925        BNR  B48,ZERO+12                           08232 45 08252 00512
18935        B    LDLBL                                 08244 49 14194 00000
18945        DORG *-3                                   08252
18955 B48    C    *+23,ZERO+1                           08252 24 08275 00501
18965        BE   SECINS,36,10                          08264 46 08416 01206
18975        C    *+23,ZERO+1                           08276 24 08299 00501
18985        BE   SECINS,16,10                          08288 46 08416 01206
18995        TR   ZERO+1,ZERO+12                        08300 31 00501 00512
19005        BNF  A25,PRSW                              08312 44 08372 08664
19015        BT   RCTY,RCTY-1                           08324 27 08618 08617
19025        TFM  G5+11,7,10                            08336 16 08591 000-7
19035        BTM  TABBY1,G5,7                           08348 17 08524 -8580
19045        WNTY LNTH-4                                08360 38 00700 00100
19055 A25    TF   INPUT+18,XDSA-3                       08372 26 00815 16528
19065        AM   INPUT2+9,7,10                         08384 11 00968 000-7
19075        TR   INPUT2+10,WRMS+16                     08396 31 00969 12694
19085        B    TYPDSA,,,TO ROUTINE TO TYPE OPERANDS OF MACRO LINKAGE 08408 49 07360 00000
19095        DORG *-3                                   08416
19105 SECINS TR   ZERO,ZERO+12                          08416 31 00500 00512
19115        AM   INPUT2+9,12                           08428 11 00968 -0012
19125        TF   INPUT2+68,INPUT2+73                   08440 26 01027 01032
19135        AM   INPUT2+73,12                          08452 11 01032 -0012
19145        BNF  A26,PRSW                              08464 44 08016 08664
19155        BT   RCTY,RCTY-1                           08476 27 08618 08617
19165        TFM  G5+11,12,10                           08488 16 08591 00032
19175        BTM  TABBY1,G5,7                           08500 17 08524 -8580
19185        B    A26                                   08512 49 08016 00000
19195 TABBY1 TBTY                                       08524 34 00000 00108
19205 TEST   DS   5,*-5                                 08530          5
19215        TBTY                                       08536 34 00000 00108
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19225 SUBENT DS   5,*-5                                  08542          5
19235 TABBY  TBTY 75000                                  08548  34  75000  00108
19245        DC   1,',*-4                                08555          1
                  '
19255        TF   G25+6,TABBY1-1                         08560  26  08578  08523
19265 G25    B                                           08572  49  00000  00000
19275        DORG *-3                                    08580
19285 G5     AM   ADDRS,5,10                             08580  11  01122  000-5
19295 SPAT   WNTY ADDRS-4                                08592  38  01118  00100
19305        SPTY                                        08604  34  00000  00101
19315 TYPADD DS   ,*-4                                   08611          0
19325        DC   1,',*-4                                08611          1
                  '
19335        BB                                          08616  42  00000  00000
19345        DORG *-9                                    08618
19355 RCTY   TDM  PRSW,0                                 08618  15  08664  00000
19365        BNC1 BB                                     08630  47  06334  00100
19375        TDM  PRSW,-1                                08642  15  08664  0000J
19385 RCTY1  RCTY                                        08654  34  00000  00102
19395 PRSW   DS   1,*-1                                  08664          1
19405        SM   RCNT,1,10                              08666  12  08709  000-1
19415        BP   BB                                     08678  46  06334  01100
19425        TFM  RCNT,6,10                              08690  16  08709  000-6
19435 RC2    RCTY                                        08702  34  00000  00102
19445 RCNT   DS   2,*-4                                  08709          2
19455        SM   RCNT,1,10                              08714  12  08709  000-1
19465        BP   RC2                                    08726  46  08702  01100
19475        TFM  RCNT,61,10                             08738  16  08709  00001
19485        BB                                          08750  42  00000  00000
19495        DORG *-9                                    08752
19505 PRDAS  BTM  LINPRT,DODS,8                          08752  17  06342  00678
19515 INST   BTM  INSTRN,FLAGGR                          08764  17  09030  -9262
19525 BI     BTM  INSTRN,DOBI                            08776  17  09030  -8824
19535 BNI    BTM  INSTRN,DOBNI                           08788  17  09030  -8844
19545 RDW    BTM  INSTRN,DORDW                           08800  17  09030  -8900
19555 K      BTM  INSTRN,DOK                             08812  17  09030  -8994
19565 DOBI   TFM  SNDOP+11,46,9                          08824  16  08891  00-46
19575        B    A27                                    08836  49  08856  00000
19585        DORG *-3                                    08844
19595 DOBNI  TFM  SNDOP+11,47,9                          08844  16  08891  00-47
19605 A27    TD   ZEPO+9,ZEPO+1                          08856  25  00509  00501
19615        TD   ZEPO+8,ZEPO                            08868  25  00508  00500
19625 SNDOP  TFM  ZEPO+1                                 08880  16  00501  -0000
19635        B    FLAGGR                                 08892  49  09262  00000
19645        DORG *-3                                    08900
19655 DORDW  TD   B49+11,ZEPO                            08900  25  08923  00500
19665 B49    TFM  SNDOP+11,3C,9                          08912  16  08891  00-30
19675 A28    TDM  ZEPO                                   08924  15  00500  00000
19685        B    A27                                    08936  49  08856  00000
19695        DORG *-3                                    08944
19705 JUST   TD   B50+11,ADDCOW                          08944  25  08967  00725
19715 B50    TD   B51+11,AJUST                           08956  25  08979  00599
19725 B51    AM   ADDCOW                                 08968  11  00725  -0000
19735        TF   ADDRS,ADDCOW                           08980  26  01122  00725
19745        BB                                          08992  42  00000  00000
19755        DORG *-9                                    08994
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19765 DOK     TFM  SNOOP+11,34,9                    08994 16 08891 00-34
19775         TD   ZERO+11,ZERO                     09006 25 00511 00500
19785         B    A28                              09018 49 08924 00000
19795 *
19805 *          ASSEMBLE INSTRUCTION
19815 *
19825 INSTRN  TR   ZERO,CLEARER+41                   09030 31 00500 00773
19835         BT   JUST,JUST-1                      09042 27 08944 08943
19845         BC   B52,EJS                          09054 43 09086 00587
19855         AM   ADDCOM,11,10                     09066 11 00725 00CJ1
19865         B    LDLHL                            09078 49 14194 00000
19875         DORG *-3                              09086
19885 B52     TF   TEMP,ADDCOM                      09086 26 00406 00725
19895         TD   ZERO,ZERO+28                     09098 25 00500 00528
19905         TD   ZERO+1,ZERO+29                   09110 25 00501 00529
19915         BTM  EVALAD,**+12,4                   09122 17 03M82 09134
19925         TF   ZERO+6,ADDRS                     09134 26 00506 01122
19935         CF   ZERO+2                           09146 33 00502 00C00
19945         BNR  B53,INPUT+20                     09158 45 09178 00817
19955         B    TYPINS                           09170 49 09214 00C00
19965         DORG *-3                              09178
19975 B53     BTM  EVALAD,**+12,5                   09178 17 03402 09190
19985         TF   ZERO+11,ADDRS                    09190 26 00511 01122
19995         CF   ZERO+7                           09202 33 00507 00000
20005 TYPINS  TF   ADDRS,ADDCOM                     09214 26 01122 00725
20015         AM   ADDCOM,11,10                     09226 11 00725 00CJ1
20025         TF   B54+6,INSTRN-1                   09238 26 09256 09029
20035 *
20045 *          BRANCH TO CHECK FOR FLAGS OR INSERT Q MODIFIER
20055 *
20065 B54     B                                     09250 49 00000 00000
20075 *
20085 *          CHECK TO SEE IF THERE IS A FLAG OPERAND
20095 *
20105 FLAGGR  BNR  B55,INPUT+20                     09262 45 09362 00817
20115         B    SETIM                            09274 49 09282 00000
20125         DORG *-3                              09282
20135 *
20145 *          SET FLAG IF IMMEDIATE INSTRUCTION
20155 *
20165 SETIM   TD   B56+9,ZERO                       09282 25 09303 00500
20175 B56     CM   *+9,1,810                        09294 14 09303 0-0-1
20185         BNE  LINPRT                           09306 47 06342 01200
20195         C    *+23,ZERO+1                      09318 24 09341 00501
20205         BE   LINPRT,15,10                     09330 46 06342 012J5
20215         SF   ZERO+7                           09342 32 00507 00000
20225         B    LINPRT                           09354 49 06342 00000
20235         DORG *-3                              09362
20245 B55     BTM  CKREC,SETIM                      09362 17 10066 -9282
20255 *
20265 *          SCAN FLAG OPERAND
20275 *
20285 TRANS   TR   INPUT+19,INPUT+21                09374 31 00816 00818
20295 B60     BNR  B57,INPUT+20                     09386 45 09406 00817
20305         B    LINPRT                           09398 49 06342 00000
20315         DORG *-3                              09406
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20325 B57     BC    B58,INPUT+19                                  09406  43  09426  00816
20335         B     TRANS                                         09418  49  09374  00000
20345         DORG  *-3                                           09426
20355 B58     CM    INPUT+20,23,10                                09426  14  00817  000K3
20365         BE    LINPRT                                        09438  46  06342  01200
20375         CM    INPUT+20,71,10                                09450  14  00817  000P1
20385         BNE   ABLE                                          09462  47  09618  01200
20395         BNR   B59,INPUT+22                                  09474  45  09494  00819
20405         B     ABLE                                          09486  49  09618  00000
20415         DORG  *-3                                           09494
20425 B59     CM    INPUT+22,70,10                                09494  14  00819  00CP0
20435         BNE   BAKR                                          09506  47  09550  01200
20445         SF    ZERO+10                                       09518  32  00510  00000
20455 CHAR    TR    INPUT+19,INPUT+23                             09530  31  00816  00820
20465         B     B60                                           09542  49  09386  00C00
20475         DORG  *-3                                           09550
20485 BAKR    CM    INPUT+22,71,10                                09550  14  00819  000P1
20495         BNE   ABLE                                          09562  47  09618  01200
20505         BNR   B61,INPUT+24                                  09574  45  09594  00821
20515         B     ZERONE                                        09586  49  09650  00000
20525         DORG  *-3                                           09594
20535 B61     CM    INPUT+24,70,10                                09594  14  00821  000P0
20545         BNE   ZERONE                                        09606  47  09650  01200
20555 ABLE    TC    B62+6,INPUT+20                                09618  25  09636  00817
20565 B62     SF    ZERO                                          09630  32  00500  00000
20575         B     TRANS                                         09642  49  09374  00000
20585         DORG  *-3                                           09650
20595 ZERONE  SF    ZERO+11,7071,810                              09650  32  00511  0P0P1
20605         B     CHAR                                          09662  49  09530  00000
20615         DORG  *-3                                           09670
20625 MACRO   BT    JUST,JUST-1                                   09670  27  08944  08943
20635 A29     SF    ZERO+28                                       09682  32  00528  00000
20645         TF    A29+11,ZERO+29                                09694  26  09693  00529
20655 *
20665 *          SET ZERO TO INDICATE SUBROUTINE IS REQUIRED
20675 *
20685         TFM   B65+6,ISTAT-30                                09706  16  09736  -0659
20695         A     B65+6,ZERO+29                                 09718  21  09736  00529
20705 B65     TCM                                                 09730  15  00000  00000
20715         B     DSA,,,TO DSA ROUTINE TO COUNT NUMBER OF OPERANDS 09742  49  13614  00000
20725         DORG  *-3                                           09750
20735 *
20745 *          ASSEMBLE LINKAGE
20755 *
20765 MAC1    TF    DSASND,ADDRS                                  09750  26  15299  01122
20775         TF    DSASND-5,ADDRS                                09762  26  15294  01122
20785         AM    DSASND,19,10                                  09774  11  15299  000J9
20795         AM    DSASND-5,14,10                                09786  11  15294  000J4
20805         TR    OUT,ZERO+1                                    09798  31  00418  00501
20815         TR    ZERO,LINK                                     09810  31  00500  01128
20825         TR    ZERO+24,OUT                                   09822  31  00524  00418
20835         A     ZERO+11,ADDRS                                 09834  21  00511  01122
20845         A     ZERO+6,PICKUP                                 09846  21  00506  02984
20855         TFM   B66+11,ENTABL-7                               09858  16  09893  -1585
20865 B67     AM    B66+11,7                                      09870  11  09893  -0007
20875 B66     C     A29+11                                        09882  24  09693  00000
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20885          BNE   B67                    09894  47  09870  01200
20895          TF    B68+11,H66+11          09906  26  09941  09893
20905          SM    B68+11,2,10            09918  12  09941  000-2
20915 R68      TF    ZEPU+18                09930  26  00518  00000
20925          CF    ZEPU+2                 09942  33  00502  00000
20935          CF    ZEPU+14                09954  33  00514  00000
20945          B     LINPRT                 09966  49  06342  00000
20955          DORG  *-3                    09974
20965 *
20975 *           EVALUATE LENGTH OF DAS
20985 *
20995 DAS      BTM   EVALAD,*+12,4          09974  17  03M82  09986
21005          TF    LNTH,ADDRS             09986  26  00704  01122
21015          TF    TEMPR,LNTH             09998  26  00730  00704
21025          A     TEMPR,TEMPR            10010  21  00730  00730
21035          TFM   F1+6,PRDAS             10022  16  10078  -8752
21045          BNR   DAC3,INPUT+20          10034  45  10080  00817
21055          TFM   G14+6,NOSINE,7         10046  16  10064  J0600
21065 G14      B     NOSINE                 10058  49  10600  00000
21075          DORG  *-3                    10066
21085 *
21095 *           ADDRESS ASSIGNED BY PROCESSOR
21105 *
21115 CKREC    TF    BR1+6,*-1              10066  26  10096  10065
21125          BNR   BR2,INPUT+22           10078  45  10098  00819
21135 BR1      B                            10090  49  00000  00000
21145          DORG  *-3                    10098
21155 BR2      CM    INPUT+22,23,10         10098  14  00819  000K3
21165          BE    BR1                    10110  46  10090  01200
21175          BB                           10122  42  00000  00000
21185          DORG  *-9                    10124
21195 *
21205 *           EVALUATE LENGTH OF DAC
21215 *
21225 DAC      TF    INPUT+18,XDAS-3        10124  26  00815  16484
21235          BTM   EVALAD,*+12,4          10136  17  03M82  10148
21245          TF    LNTH,ADDRS             10148  26  00704  01122
21255          CM    LNTH,51                10160  14  00704  -0051
21265          BNN   ERCON                  10172  46  12826  01300
21275          A     ADDRS,ADDRS            10184  21  01122  01122
21285          TF    TEMPR,ADDRS            10196  26  00730  01122
21295          BNR   B71,INPUT+20           10208  45  10228  00817
21305          B     ERCON                  10220  49  12826  00000
21315          DORG  *-3                    10228
21325 B71      BNR   B72,INPUT+22           10228  45  10248  00819
21335          B     ERCON                  10240  49  12826  00000
21345          DORG  *-3                    10248
21355 B72      TFM   CHVALD+11,INPUT+19     10248  16  10283  -0816
21365          A     CHVALD+11,TEMPR        10260  21  10283  00730
21375 CHVALD   TR    OUT+2                  10272  31  00420  00000
21385          BNR   B73,OUT+3              10284  45  10304  00421
21395          B     ERCON                  10296  49  12826  00000
21405          DORG  *-3                    10304
21415 B73      BNR   B74,OUT+5              10304  45  10324  00423
21425          B     B75                    10316  49  10348  00000
21435          DORG  *-3                    10324
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21445 B74     CM    OUT+5,23,10                          10324  14  00423  000K3
21455 STCHAR  BNE   ERCON                                10336  47  12826  01200
21465 B75     TD    STCHAR+11,OUT+5                      10348  25  10347  00423
21475         AM    CHVALD+11,3                          10360  11  10283  -0003
21485         TF    B76+6,CHVALD+11                      10372  26  10390  10283
21495 B76     TFM   ,,10                                 10384  16  00000  000-0
21505         DC    1,',*
*                                                        10395          1
21515         CM    OUT+3,34,10                          10396  14  00421  000L4
21525         BNE   A32                                  10408  47  10456  01200
21535         TF    B77+6,CHVALD+11                      10420  26  10450  10283
21545         SM    B77+6,2,10                           10432  12  10450  000-2
21555 B77     TFM   ,,10                                 10444  16  00000  000-0
21565         DC    1,',*
*                                                        10455          1
21575 A32     TR    OUT+2,INPUT+21                       10456  31  00420  00818
21585         TF    B78+11,CHVALD+11                     10468  26  10503  10283
21595         AM    B78+11,1                             10480  11  10503  -0001
21605 B78     TR    INPUT+21                             10492  31  00818  00000
21615         TFM   B79+6,OUT+4                          10504  16  10546  -0422
21625         A     B79+6,TEMPR                          10516  21  10546  00730
21635 B80     SM    B79+6,2,10                           10528  12  10546  000-2
21645 B79     CF                                         10540  33  00000  00000
21655         CM    B79+6,OUT+4                          10552  14  10546  -0422
21665         BNE   B80                                  10564  47  10528  01200
21675         BNR   DAC3,STCHAR+11                       10576  45  10680  10347
21685 *          ADDRESS ASSIGNED BY PROCESSOR
21695 *
21705         TFM   F1+6,F2                              10588  16  10678  J0704
21715 NOSINE  BT    JUST,JUST-1                          10600  27  08944  08943
21725         AM    ADDCOM,1                             10612  11  00725  -0001
21735         AM    ADDRS,1                              10624  11  01122  -0001
21745         A     ADDCOM,TEMPR                         10636  21  00725  00730
21755         SM    ADDCOM,2,10                          10648  12  00725  000-2
21765 F3      BNR   LDLBL,EJS                            10660  45  14194  00587
21775 F1      B                                          10672  49  00000  00000
21785         DORG  *-3                                  10680
21795 DAC3    BTM   CKREC,NOSINE                         10680  17  10066  J0600
21805         BTM   EVALAD,F3,5                          10692  17  03402  10660
21815 F2      TF    CONSND-5,ADDRS                       10704  26  15275  01122
21825         SM    CONSND-5,1                           10716  12  15275  -0001
21835         TF    CONSND,CONSND-5                      10728  26  15280  15275
21845         A     CONSND,TEMPR                         10740  21  15280  00730
21855         BTM   LINPRT,PCON                          10752  17  06342  -7520
21865 *
21875 *          EVALUATE LENGTH OF DSB
21885 *
21895 DSB     TF    INPUT+18,XDS-3                       10764  26  00815  16462
21905         BTM   EVALAD,*+12,4                        10776  17  03M82  10788
21915         TF    LNTH,ADDRS                           10788  26  00704  01122
21925         BNR   B83,INPUT+20                         10800  45  10832  00817
21935 A33     TFM   EVALER-1,70000                       10812  16  05105  P0000
21945         DC    1,',*
*                                                        10823          1
21955         B     A34                                  10824  49  12838  00000
21965         DORG  *-3                                  10832
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21975 B83     BTM  CKREC,A33                          10832  17  10066  J0812
21985 *
21995 *          EVALUATE NUMBER OF ELEMENTS OF DSB
22005 *
22015          BTM  LVALAD,*+12,5                     10844  17  03462  10856
22025          TF   TEMPR,ADDRS                       10856  26  00730  01122
22035 SEN      BNR  ASINE,INPUT+20,4                  10868  45  10R76  00817
22045 *
22055 *          ADDRESS ASSIGNED BY PROCESSOR
22065 *
22075 A35      A    ADDCON,LNTH                       10880  21  00725  00704
22085          M    LNTH,ADDRS                        10892  23  00704  01122
22095          SF   95                                10904  32  00095  00000
22105          S    99,LNTH                           10916  22  00099  00704
22115          TF   ADDRS,ADDCON                      10928  26  01122  00725
22125          A    ADDCON,99                         10940  21  00725  00099
22135          BNR  LDLBL,EJS                         10952  45  14194  00587
22145          BTM  LINPRT,DODSB                      10964  17  06342  -6642
22155 ASINE    BTM  CKREC,A35                         10976  17  10066  J0880
22165 *
22175 *          ADDRESS ASSIGNED BY PROGRAMMER
22185 *
22195          BTM  EVALAD,*+12,5                     10988  17  03402  11000
22205          BNR  LDLBL,EJS                         11000  45  14194  00587
22215 PRDSB    BTM  LINPRT,DODSB                      11012  17  06342  -6642
22225 *
22235 *          EVALUATE LENGTH OF DS OR DNB
22245 *
22255 DSDNB    BTM  EVALAD,*+12,4                     11024  17  03M82  11036
22265          TF   LNTH,ADDRS                        11036  26  00704  01122
22275          BC   B84,ZERO+29                       11048  43  11084  00529
22285          CM   LNTH,51                           11060  14  00704  -0051
22295 *
22305 *          BRANCH IF LENGTH OF DNB IS GREATER THAN 50
22315 *
22325          BNN  ERCON                             11072  46  12826  01300
22335 B84      BNR  NASS,INPUT+20                     11084  45  11188  00817
22345 *
22355 *          ADDRESS ASSIGNED BY PROCESSOR
22365 *
22375 A36      TF   ADDRS,ADDCON                      11096  26  01122  00725
22385          A    ADDCON,LNTH                       11108  21  00725  00704
22395          BC   DSS,ZERO+28                       11120  43  11152  00528
22405          A    ADDRS,LNTH                        11132  21  01122  00704
22415          B    A1                                11144  49  11164  00000
22425          DORG *-3                               11152
22435 DSS      AM   ADDRS,1,10                        11152  11  01122  000-1
22445 A1       BNR  LDLBL,EJS                         11164  45  14194  00587
22455 PRDS     BTM  LINPRT,DODS                       11176  17  06342  -6678
22465 NASS     BTM  CKREC,A36                         11188  17  10066  J1096
22475 *
22485 *          ADDRESS ASSIGNED BY PROGRAMMER
22495 *
22505          BTM  EVALAD,A1,5                       11200  17  03402  11164
22515 MORG     BTM  EVALAD,*+12,4                     11212  17  03M82  11224
22525          AM   ADDCON,1                          11224  11  00725  -0001
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22535          TF   SHEILA+11,ADDCOW      11236 26 11283 00725
22545 LYNN     S    SHEILA+11,ADDRS       11248 22 11283 01122
22555          BP   LYNN                  11260 46 11248 01100
22565 SHEILA   SM   ADDCOW                11272 12 00725 -0000
22575          TF   ADDRS,ADDCOW          11284 26 01122 00725
22585          B    G1                    11296 49 11328 00000
22595          DORG *-3                   11304
22605 DORG     BTM  EVALAD,*+12,4         11304 17 03M82 11316
22615          TF   ADDCOW,ADDRS          11316 26 00725 01122
22625 *
22635 *          SET ADDRESS COUNTER TO NEW VALUE
22645 *
22655 G1       SM   ADDCOW,1,10           11328 12 00725 000-1
22665          BNN  B85                   11340 46 11364 01300
22675          TFM  ADDCOW,99999          11352 16 00725 R9999
22685 B85      BNR  LOLBL,EJS             11364 45 14194 00587
22695          CF   ADDRS-4               11376 33 01118 00000
22705          BNF  A8,PRSW               11388 44 05518 08664
22715          WNTY ADDRS-4               11400 38 01118 00100
22725          BTM  LINE,*+12             11412 17 06502 J1424
22735          BT   PCHCRD,PCHCRD-1[a]    11424 27 06262 06261
22745          B    LOLBL                 11436 49 14194 00000
22755          DORG *-3                   11444
22765 *
22775 *          EVALUATE ADDRESS OF DEND
22785 *
22795 DEND     BTM  EVALAD,*+12,4         11444 17 03M82 11456
22805          TFM  MESS1+24,49,10        11456 16 01195 000M9
22815 *
22825 *          BRANCH IF PASSII
22835 *
22845          BC   OVER,EJS              11468 43 11536 00587
22855          BD   PASS1,ZERO+29         11480 43 02426 00529
22865          TFM  MESS1+24,,10          11492 16 01195 000-0
22875          BC1  A38                   11504 46 11714 00100
22885 PNCH11   WACD INPUT2-10             11516 39 00949 00400
22895          B    A38                   11528 49 11714 00000
22905          DORG *-3                   11536
22915 OVER     TF   GOTO,ADDRS            11536 26 15132 01122
22925          CF   ADDRS-4               11548 33 01118 00000
22935 L        DC   3,G,*                 11559     3
               -00
22945          BC   H88,ZERO+29           11560 43 11630 00529
22955          TDM  GOTO-17,8             11572 15 15115 00008
22965          B    B87                   11584 49 11642 00000
22975          DORG *-3                   11592
22985 B891     BNC3 B8                    11592 47 06334 00300
22995          CM   SIXTY,60              11604 14 13337 -0060
23005          BNE  A17                   11616 47 06002 01200
23015          BB                         11628 42 00000 00000
23025          DORG *-9                   11630
23035 B88      TDM  GOTO-17,1             11630 15 15115 00C01
23045 B87      BNF  B89,PRSW              11642 44 11666 08664
23055          WNTY ADDRS-4               11654 38 01118 00100
23065 B89      BT   B891,B891-1           11666 27 11592 11591
23075          BTM  LINE,*+12             11678 17 06502 J1690
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23085          BT    PCHCRD,PCHCRD-1                    11690  27  06262  06261
23095          BC    A41,ZERO+29                        11702  43  12138  00529
23105 A38      BT    RCTY,RCTY-1                        11714  27  08618  08617
23115 CSTAT    C     IISTAT,ISTAT                       11726  24  15113  00689
23125 *
23135 *          BRANCH IF SUBROUTINES ARE TO BE LOADED
23145 *
23155          BNE   MACROS                             11738  47  12434  01200
23165          BD    A41,EJS                            11750  43  12138  00587
23175 A48      WATY  MESS1                              11762  39  01171  00100
23185          TC    EJS,RECMK                          11774  25  00587  01796
23195 *
23205 *          PRINT SYMBOL TABLE AND PROCEED TO PASS II
23215 *
23225 PRSYM    TFM   SNT+11,SYMTBL-1                    11786  16  11893  J6817
23235 A43      TDM   *+10,5,7                           11798  15  11808  -0005
23245          BT    RCTY,RCTY-1                        11810  27  08618  08617
23255 A44      TR    ZERO,CLEAR+30                      11822  31  00500  00762
23265          TFM   SYM1+11                            11834  16  11973  -0000
23275          TFM   SYM2+6,ZERO+3                      11846  16  11992  -0503
23285          AM    SNT+11,1,10                        11858  11  11893  000-1
23295          BC4   G30                                11870  46  11894  00400
23305 SNT      BC    B93                                11882  43  11914  00000
23315 G30      H                                        11894  48  00000  00000
23325 SEVENS   DC    7,7070707,*                        11905          7
               P070707
23335          B     INIT2                              11906  49  01810  00000
23345          DORG  *-3                                11914
23355 B93      TF    B94+11,SNT+11                      11914  26  11937  11893
23365 B94      TD    SYM1+11                            11926  25  11973  00000
23375          TF    SYM2+11,B94+11                     11938  26  11997  11937
23385          A     SYM1+11,SYM1+11                    11950  21  11973  11973
23395 SYM1     AM    SYM2+6                             11962  11  11992  -0000
23405          A     SYM2+11,SYM1+11                    11974  21  11997  11973
23415 SYM2     TF                                       11986  26  00000  00000
23425          TF    SNT+11,SYM2+11                     11998  26  11893  11997
23435          AM    SNT+11,5,10                        12010  11  11893  000-5
23445          TF    B95+11,SNT+11                      12022  26  12045  11893
23455 B95      TF    ADDRS                              12034  26  01122  00000
23465          CF    ADDRS-4                            12046  33  01118  00000
23475          WNTY  ADDRS-4                            12058  38  01118  00100
23485          BNF   B96,ZERO+15                        12070  44  12094  00515
23495          TFM   ZERO+3,14,8                        12082  16  00503  0-014
23505 B96      WATY  ZERO+1                             12094  39  00501  00100
23515          SM    A43+10,1,10                        12106  12  11808  000-1
23525          BP    A44                                12118  46  11822  01100
23535          B     A43                                12130  49  11798  00000
23545          DORG  *-3                                12138
23555 A41      TR    INPUT2+5,BRSQ+1                    12138  31  00964  15352
23565          TR    INPUT2+27,BRSQ+23                  12150  31  00986  15374
23575          BT    A5,A5-1                            12162  27  06274  06273
23585          TR    INPUT2,TBLCRD                      12174  31  00959  14998
23595          BT    A5,A5-1                            12186  27  06274  06273
23605          TR    OUT,TABCON-3                       12198  31  00418  15326
23615 *
23625 *          PUNCH ARITHMETIC TABLES
```

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23635 *
23645 PTBL   TF   INPUT2+79,BLNKS-60                    12210  26  01038  15208
23655        TF   B90+6,OUT+6                          12222  26  12240  00424
23665 B90    TD   ,RECMK                               12234  25  00000  01796
23675        TF   B91+11,OUT+2                         12246  26  12269  00420
23685 B91    TR   INPUT2                               12258  31  00959  00000
23695        TDM  INPUT2+75,,11                        12270  15  01034  0000-
23705        BT   A5,A5-1                              12282  27  06274  06273
23715        TF   B92+6,OUT+6                          12294  26  12312  00424
23725 B92    TD   ,OUT+3                               12306  25  00000  00421
23735        TR   OUT,OUT+4                            12318  31  00418  00422
23745        BNR  PTBL,OUT+3                           12330  45  12210  00421
23755 *
23765 *         PUNCH  HALT AND PROCEED
23775 *
23785        TR   INPUT2,GOTO-18                       12342  31  00959  15114
23795        TR   INPUT2+32,GOTO+14                    12354  31  00991  15146
23805        BT   A5,A5-1                              12366  27  06274  06273
23815        BC   PLDR,ZEPO+29                         12378  43  02586  00529
23825        WATY MESS1                                12390  39  01171  00100
23835 *
23845 *         HALT AND PROCEED TO PROCESS PASSI OF NEW PROGRAM
23855 *         OR PASSII OF SAME PROGRAM AGAIN IF SW. 3 IS ON
23865 *
23875 A42    H                                         12402  48  00000  00000
23885 BETA   DS   10,*                                 12413        10
23895        BC3  INIT2                                12414  46  01810  00300
23905        B    INITI                                12426  49  01798  00000
23915        ORG  *-3                                  12434
23925 *
23935 *         STORE ADDRESSES OF PICK ROUTINE AND SECONDARY LINKAGES OF
23945 *         SUBROUTINES USED
23955 *
23965 MACROS BC   WRMS,EJS                             12434  43  12678  00587
23975        BT   JUST,JUST-1                          12446  27  08944  08943
23985        TF   SUBENT,ADDCON                        12458  26  08542  00725
23995 DIN    TFM  CNTR,,10                             12470  16  02521  000-0
24005        TFM  DJD+11,ISTAT-30                      12482  16  12565  -0659
24015        TFM  A45+6,ENTABL-7                       12494  16  12584  -1585
24025 A47    AM   CNTR,1,10                            12506  11  02521  000-1
24035        AM   DJD+11,1,10                          12518  11  12565  000-1
24045        CM   DJD+11,ISTAT                         12530  14  12565  -0689
24055        BE   A46                                  12542  46  12646  01200
24065 DJD    BD   A47                                  12554  43  12506  00000
24075        AM   A45+6,7,10                           12566  11  12584  000-7
24085 A45    TF   ,CNTR                                12578  26  00000  02521
24095        TF   B99+6,A45+6                          12590  26  12620  12584
24105        SM   B99+6,2,10                           12602  12  12620  000-2
24115 B99    TF   ,SUBENT                              12614  26  00000  08542
24125        AM   SUBENT,20,10                         12626  11  08542  000K0
24135        B    A47                                  12638  49  12506  00000
24145        ORG  *-3                                  12646
24155 A46    TF   PICKUP,SUBENT                        12646  26  02984  08542
24165        TC   NOISE,OUT+3,,STORE NOISY DIGIT       12658  25  14697  00421
24175        B    A48                                  12670  49  11762  00000
24185        ORG  *-3                                  12678
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24195 WRMS   WATY MESS2                                  12678  39  01201  00100
24205        H                                           12690  48  00000  00000
24215        DC   8,5',*                                 12701          8
             -000005'
24225        DNB  2,*-6                                  12695          2
24235 *
24245 *         LOAD SUBROUTINE PROCESSOR
24255 *
24265        B    BRLUAD                                 12702  49  15354  00000
24275        DORG *-3                                    12710
24285 *
24295 *         DEFINE CONSTANT AND DEFINE SPECIAL CONSTANT
24305 *
24315 DC     BD   D2,ZEPO+28                             12710  43  12742  00528
24325        TF   INPUT+18,XDS-3                         12722  26  00815  16462
24335        B    D1                                     12734  49  12754  00C00
24345        DORG *-3                                    12742
24355 D2     TF   INPUT+18,XDSS-3                        12742  26  00815  16473
24365 D1     TD   DC-1,ZEPO+28                           12754  25  12709  00528
24375        BTM  EVALAD,**12,4                          12766  17  03M82  12778
24385        TF   LNTH,ADDRS                             12778  26  00704  01122
24395        CM   LNTH,51                                12790  14  00704  -0051
24405        BNN  ERCON                                  12802  46  12826  01300
24415        BNR  D3,INPUT+20                            12814  45  12922  00817
24425 ERCON  TFM  EVALER-1,80000                         12826  16  05105  G0000
24435        DC   1,',*                                  12837          1
             '
24445 A34    TR   INPUT+19,ELNGTH-1                      12838  31  00816  01263
24455        BT   EPRINT,EPRINT-1                        12850  27  05310  05309
24465        BC2  A7                                     12862  46  05142  00200
24475        TF   PLACE,ADDCOM                           12874  26  06365  00725
24485        BNR  OP,EJS                                 12886  45  03002  00587
24495        BT   RCTY1,RCTY1-1                          12898  27  08654  08653
24505        BTM  TABBY1,OP,7                            1291U  17  08524  -3002
24515 D3     TR   ZEPO-1,CLERER                          12922  31  00499  00732
24525        SF   ZEPU                                   12934  32  00500  00000
24535        TDM  SFLAG+1,3                              12946  15  13135  00003
24545        B    A70                                    12958  49  13102  00000
24555        DORG *-3                                    12966
24565 CCOMER CM   INPUT+22,23,10                         12966  14  00819  000K3
24575        BE   A50                                    12978  46  13114  01200
24585        BH   A51                                    12990  46  13054  01100
24595        BC   ERCON,INPUT+22                         13002  43  12826  00819
24605        BC   D4,INPUT+21                            13014  43  13034  00818
24615        B    TRREC                                  13026  49  13090  00000
24625        DORG *-3                                    13034
24635 D4     TDM  SFLAG+1,2                              13034  15  13135  00002
24645        B    TRREC                                  13046  49  13090  00000
24655        DORG *-3                                    13054
24665 *
24675 *         COLLECT CONSTANT
24685 *
24695 A51    TF   SFLAG+11,INPUT+22                      13054  26  13145  00819
24705        TD   ZEPO+51,INPUT+22                       13066  25  00551  00819
24715        TR   ZEPO,ZEPO+1                            13078  31  00500  00501
24725 TRREC  TR   INPUT+19,INPUT+21                      13090  31  00816  00818
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24735 A70      BNR  CCOMER,INPUT+22                    13102  45  12966  00819
24745 A50      BNF  SFLAG,ZERO                         13114  44  13134  00500
24755          B    ERCON                              13126  49  12826  00000
24765          DORG *-3                                13134
24775 SFLAG    SF   ZERO+50                            13134  32  00550  00000
24785          CM   SFLAG+11,34,10                     13146  14  13145  000L4
24795          BNE  A52                                13158  47  13206  01200
24805          BNF  D5,ZERO+50                         13170  44  13194  00550
24815          SF   ZERO+49                            13182  32  00549  00000
24825 D5       TC   ZERO+50,RECMK                      13194  25  00550  01796
24835 A52      SF   ZERO                               13206  32  00500  00000
24845 TESTAD   DS   5,*                                13217         5
24855          TFM  D6+6,ZERO+50                       13218  16  13248  -0550
24865          S    D6+6,LNTH                          13230  22  13248  00704
24875 D6       C    ,CLEREK+49                         13242  24  00000  00781
24885          BNE  ERCON                              13254  47  12826  01200
24895          TF   D7+11,D6+6                         13266  26  13289  13248
24905 D7       TR   ZERO                               13278  31  00500  00000
24915          BD   D8,DC-1                            13290  43  13314  12709
24925          SF   ZERO+1                             13302  32  00501  00000
24935 SET      DC   1,D,*                              13313         1
               -
24945 SET2     DC   1,0,*-1                            13312         1
               -
24955 D8       BNR  D9,ZERO+1                          13314  45  13338  00501
24965          CF   ZERO+1                             13326  33  00501  00000
24975 SIXTY    DC   5,60,*                             13337         5
               -C060
24985 D9       BNR  CHECK,INPUT+22                     13338  45  13502  00819
24995 *
25005 *          ADDRESS ASSIGNED BY PROCESSOR
25015 *
25025 GOAHD    TF   ADDRS,ADDCOM                       13350  26  01122  00725
25035          A    ADDCOM,LNTH                        13362  21  00725  00704
25045          TF   CONSND,ADDCOM                      13374  26  15280  00725
25055          AM   CONSND,1,10                        13386  11  15280  000-1
25065          BD   DSC,DC-1                           13398  43  13430  12709
25075          A    ADDRS,LNTH                         13410  21  01122  00704
25085          B    A53                                13422  49  13442  00000
25095          DORG *-3                                13430
25105 DSC      AM   ADDRS,1,10                         13430  11  01122  000-1
25115 A53      BNR  LDLBL,EJS                          13442  45  14194  00587
25125          TR   OUT+2,ZERO+1                       13454  31  00420  00501
25135          TF   CONSND-5,CONSND                    13466  26  15275  15280
25145          S    CONSND-5,LNTH                      13478  22  15275  00704
25155 PRDCSA   BTM  LINPRT,PCON                        13490  17  06342  -7520
25165 CHECK    TR   INPUT+19,INPUT+21                  13502  31  00816  00818
25175          BTM  CKREC,GOAHD                        13514  17  10066  J3350
25185          TR   INPUT+19,INPUT+21                  13526  31  00816  00818
25195 *
25205 *          ADDRESS ASSIGNED BY PROGRAMMER
25215 *
25225          BTM  EVALAD,*+12,4                      13538  17  03M82  13550
25235          TF   CONSND,ADDRS                       13550  26  15280  01122
25245          BD   L11,DC-1                           13562  43  13594  12709
25255          AM   CONSND,1,10                        13574  11  15280  000-1
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25265          B     A53                          13586  49  13442  00000
25275          DORG  *-3                          13594
25285 D11      A     CONSND,LNTH                  13594  21  15280  00704
25295          B     A53                          13606  49  13442  00000
25305          DORG  *-3                          13614
25315 DSA      TFM   TRDSA+6,96,10                13614  16  13896  000R6
25325          CF    GOEVAL+5                     13626  33  13655  00000
25335          BNR   A54,EJS                      13638  45  13830  00587
25345 *
25355 *          COLLECT OPERANDS
25365 *
25375 GOEVAL   BTM   EVALAD,*+12,4                13650  17  03M82  13662
25385          AM    TRDSA+6,5,10                 13662  11  13896  000-5
25395          CM    TRDSA+6,51,10                13674  14  13896  000N1
25405          BL    TRDSA                        13686  47  13890  01300
25415 LRDSA    TFM   EVALER-1,60000               13698  16  05105  00000
25425          DC    1,',*                        13709          1
               '
25435          BT    EPRINT,EPRINT-1              13710  27  05310  05309
25445          BC2   A7                           13722  46  05142  00200
25455          TFM   TRDSA+5,51,10                13734  16  13895  000N1
25465          BNR   A56,EJS                      13746  45  13938  00587
25475          BT    RCTY1,RCTY1-1                13758  27  08654  08653
25485          BTM   TABBY1,A57,7                 13770  17  08524  J3902
25495 *
25505 *          DURING PASS1 COUNT NUMBER OF OPERANDS
25515 *
25525 A55      CM    INPUT+20,23,10               13782  14  00817  000K3
25535          BNE   D12                          13794  47  13818  01200
25545          AM    TRDSA+6,5,10                 13806  11  13896  000-5
25555 D12      TR    INPUT+19,INPUT+21            13818  31  00816  00818
25565 A54      BNR   A55,INPUT+20                 13830  45  13782  00817
25575          AM    TRDSA+6,5,10                 13842  11  13896  000-5
25585          CM    TRDSA+6,51,10                13854  14  13896  000N1
25595          BNN   ERDSA                        13866  46  13698  01300
25605          B     A56                          13878  49  13938  00000
25615 TRDSA    TR    ZEPO,ADDRS-4                 13890  31  00500  01118
25625 A57      SF    GOEVAL+5                     13902  32  13655  00C00
25635          BNR   GOEVAL,INPUT+20              13914  45  13650  00817
25645          TFM   LNTH,5                       13926  16  00704  -0005
25655 A56      TF    A58+11,ADDCOW                13938  26  14021  00725
25665          AM    ADDCOW,5,10                  13950  11  00725  000-5
25675          TF    A59+11,ADDCOW                13962  26  14053  00725
25685          A     ADDCOW,TRDSA+6               13974  21  00725  13896
25695          SM    ADDCOW,1,10                  13986  12  00725  000-1
25705 AERB     BNF   A59,GOODB+11                 13998  44  14042  03353
25715 A58      TFM   ADDRS                        14010  16  01122  -0000
25725          AM    ADDCOW,18,10                 14022  11  00725  000J8
25735          B     D13                          14034  49  14054  00000
25745          DORG  *-3                          14042
25755 A59      TFM   ADDRS                        14042  16  01122  -0000
25765 D13      BNR   LDLBL,EJS                    14054  45  14194  00587
25775          BNF   D14,GOODB+11                 14066  44  14086  03353
25785          B     MAC1                         14078  49  09750  00000
25795          DORG  *-3                          14086
25805 D14      TF    DSASND,ADDRS                 14086  26  15299  01122
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25815          SM    DSASND,4                                  14098  12  15299  -0004
25825          TF    DSASND-5,DSASND                           14110  26  15294  15299
25835          SM    DSASND-5,5                                14122  12  15294  -0005
25845          BTM   LINPRT,TYPDSA                             14134  17  06342  -7360
25855 *
25865 *          TRANSFER INSTRUCTION ROUTINE
25875 *
25885 TRA      BT    JUST,JUST-1                               14146  27  08944  08943
25895          AM    ADDLOW,23                                 14158  11  00725  -0023
25905          TR    ZERO,TRAC-24                              14170  31  00500  01270
25915          BC    LINPRT,EJS                                14182  43  06342  00587
25925 *
25935 *          ROUTINE TO LOAD LABELS INTO SYMBOL TABLE
25945 *
25955 LDLBL    C     CLERER+11,INPUT+10                        14194  24  00743  00807
25965          BNE   F9                                        14206  47  14226  01200
25975 LABCTR   DS    2,*                                       14217          2
25985          B     A37                                       14218  49  02546  00000
25995          DORG  *-3                                       14226
26005 F9       TDM   TSPEC+11,1                                14226  15  14353  00001
26015          TF    LAB,INPUT+10                              14238  26  01261  00807
26025          TFM   LABCTR,6,10                               14250  16  14217  000-6
26035 A61      BC    A60,LAB                                   14262  43  14318  01261
26045          BC    A60,LAB-1                                 14274  43  14318  01260
26055          SM    LABCTR,1,10                               14286  12  14217  000-1
26065          TF    LAB,LAB-2                                 14298  26  01261  01259
26075          B     A61                                       14310  49  14262  00000
26085          DORG  *-3                                       14318
26095 A60      TF    INPUT3,LAB                                14318  26  01585  01261
26105          SF    INPUT3                                    14330  32  01585  00000
26115 HED      DS    3,*                                       14341          3
26125 TSPEC    SF    LAB-11                                    14342  32  01250  00000
26135          CM    LAB-10,3,10                               14354  14  01251  000-3
26145          BE    A62                                       14366  46  14450  01200
26155          CM    LAB-10,21,10                              14378  14  01251  000K1
26165          BE    A62                                       14390  46  14450  01200
26175          CM    LAB-10,33,10                              14402  14  01251  000L3
26185          BL    ER14                                      14414  47  14698  01300
26195          CM    LAB-10,69,10                              14426  14  01251  00009
26205          BH    LBLOK                                     14438  46  14462  01100
26215 A62      TDM   TSPEC+11,0                                14450  15  14353  00000
26225 LBLOK    TR    LAB-11,LAB-9                              14462  31  01250  01252
26235          BNR   TSPEC,LAB-11                              14474  45  14342  01250
26245          BC    ER14,TSPEC+11                             14486  43  14698  14353
26255 LDHED    CM    LABCTR,6,10                               14498  14  14217  000-6
26265          BE    BIT                                       14510  46  14642  01200
26275          CF    INPUT3                                    14522  33  01585  00000
26285          AM    LABCTR,1,10                               14534  11  14217  000-1
26295          TFM   D17+11,INPUT3                             14546  16  14581  -1585
26305 D18      SM    D17+11,1,10                               14558  12  14581  000-1
26315 D17      BNF   D18                                       14570  44  14558  00000
26325          TF    D19+6,D17+11                              14582  26  14600  14581
26335 D19      CF                                              14594  33  00000  00000
26345          TF    D20+6,D19+6                               14606  26  14636  14600
26355          SM    D20+6,1,10                                14618  12  14636  000-1
26365 D20      TF    ,HED                                      14630  26  00000  14341
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26375 BIT     TFM  D33+6,G11                                  14642 16 04952 J4822
26385         BT   IT,IT-1                                    14654 27 04922 04921
26395 *          MULTIPLY DEFINED LABEL PASSI OR INCURRECT ADDRESS PASSII
26405         BC   D30,EJS                                    14666 43 14738 00587
26415 ER10    TFM  EVALER-1,17000                             14678 16 05105 J7C00
26425         DC   1,',*                                      14689       1
              '
26435         B    A64                                        14690 49 05722 00000
26445         ORG  *-3                                        14698
26455 NOISE   DS   1,*                                        14697       1
26465 ER14    TFM  EVALER-1,17400                             14698 16 05105 J7400
26475         DC   1,',*                                      14709       1
              '
26485         B    A64                                        14710 49 05722 00000
26495         ORG  *-3                                        14718
26505 ER9     TFM  EVALER-1,90000                             14718 16 05105 R0000
26515         DC   1,',*                                      14729       1
              '
26525         B    A64                                        14730 49 05722 00000
26535         ORG  *-3                                        14738
26545 D30     TF   D32+11,D26+11                              14738 26 14773 05C49
26555         AM   D32+11,5,7                                 14750 11 14773 -0005
26565 D32     C    ADDRS                                      14762 24 01122 00000
26575         BC2  D34                                        14774 46 14966 00200
26585         BE   G11                                        14786 46 14822 01200
26595         BT   RCTY1,RCTY1-1                              14798 27 08654 08653
26605         BTM  TABBY1,ER10,7                              14810 17 08524 J4678
26615 G11     C    A63+11,FINAL                               14822 24 04945 15431
26625 *          LABEL TABLE IS FULL
26635         BR   ER9                                        14834 46 14718 01100
26645         TF   U21+6,A63+11                               14846 26 14864 04945
26655 D21     TD   ,LABCTR                                    14858 25 00000 14217
26665         A    LABCTR,LABCTR                              14870 21 14217 14217
26675         TF   D22+6,D21+6                                14882 26 14912 14864
26685         A    D22+6,LABCTR                               14894 21 14912 14217
26695 D22     TF   ,INPUT3                                    14906 26 00000 01585
26705         AM   D22+6,5,10                                 14918 11 14912 000-5
26715         TF   D23+6,D22+6                                14930 26 14960 14912
26725         SR   ADDRS-4                                    14942 32 01118 00000
26735 D23     TF   ,ADDRS                                     14954 26 00000 01122
26745 D34     TF   ERLAB+10,INPUT+10                          14966 26 01165 00807
26755         TFM  INKRM                                      14978 16 15082 -0000
26765         B    A37                                        14990 49 02546 00000
26775         ORG  *-3                                        14998
26785 TBLCRD  RN   100,500                                    14998 36 00100 00500
26795         RN   172,500                                    15010 36 00172 00500
26805         RN   244,500                                    15022 36 00244 00500
26815         RN   316,500                                    15034 36 00316 00500
26825         RN   ,500                                       15046 36 00000 00500
26835         DNB  15                                         15072       15
26845         DC   1,0                                        15073       1
              -
26855         DC   4,'                                        15077       4
              -00'
26865 INKRM   DS   5                                          15082       5
26875         DC   1,'                                        15083       1
              '
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26885 TISTAT DC   30,111111111111111111111111111110                15113   30
              J111111111111111111111111111110
26895 GOTO   DC   19,480000000C00490C000                           15132   19
              M80C00000000004900000
26905        DC   1,6                                              15133    1
              0
26915        DC   3,-790                                           15136    3
              P9-
26925        DC   2,-12                                            15138    2
              JK
26935        DC   2,-34                                            15140    2
              LM
26945        DC   2,-56                                            15142    2
              NO
26955        DC   3,-78'                                           15145    3
              PQ'
26965        DNB  4                                                15149    4
26975        DC   12,310038800019                                  15161   12
              L10038800019
26985        DC   12,490000000000                                  15173   12
              M90C00000000
26995        DC   12,490003600000                                  15185   12
              M90003600000
27005        DNB  3                                                15188    3
27015        DC   1,0                                              15189    1
              -
27025        DC   4,'                                              15193    4
              -00'
27035        DC   1,0                                              15194    1
              -
27045        DNB  37                                               15231   37
27055 BLNKS  DNB  37                                               15268   37
27065 CONSND DC   12,60000000000                                   15280   12
              -60000000000
27075        DNB  1                                                15281    1
27085        DC   1,0                                              15282    1
              -
27095        DNB  4                                                15286    4
27105        DC   1,'                                              15287    1
              '
27115 DSASND DC   12,180000000000                                  15299   12
              J80000000000
27125        DNB  1                                                15300    1
27135        DC   1,9                                              15301    1
              R
27145        DNB  4                                                15305    4
27155        DC   1,'                                              15306    1
              '
27165 INSND  DC   12,110000000000                                  15318   12
              J10000000000
27175        DNB  1                                                15319    1
27185        DC   1,9                                              15320    1
              R
27195        DNB  4                                                15324    4
27205        DC   1,'                                              15325    1
              '
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27215 TABCON DC   4,1007                                          15329          4
             J007
27225        DC   4,1728                                          15333          4
             J728
27235        DC   4,2447                                          15337          4
             K447
27245        DC   4,-3166                                         15341          4
             L160
27255        DC   4,388'                                          15345          4
             L88'
27265 BRSQ   DS   6                                               15351          6
27275        DNB  2                                               15353          2
27285 BRLOAD RNCD 0                                               15354  36  00000  00500
27295        B    0                                               15366  49  00000  00000
27305        DORG *-4                                             15373
27315        DC   1,'                                             15373          1
             '
27325        DNB  35                                              15408         35
27335        DC   2,8                                             15410          2
             -8
27345        DC   5,96                                            15415          5
             -0096
27355        DC   5,115                                           15420          5
             -0115
27365        DNB  1                                               15421          1
27375        DC   1,0                                             15422          1
             -
27385        DC   4,'                                             15426          4
             -00'
27395 FINAL  DS   5                                               15431          5
27405 *
27415 *          OPERATION CODE TABLE
27425 *
27435 A      DC   11,-41000000215,,      ADD                      15442         11
             M100000021N
27445        DC   11,-4154000C0115,,     ADD IMMEDIATE            15453         11
             M154000011N
27455        DC   11,-46414444015,,      FLOATING ADD             15464         11
             M641444401N
27465        DC   11,-62000000225,,      SUBTRACT                 15475         11
             U200000022N
27475        DC   11,-6254000C0125,,     SUBTRACT IMMEDIATE       15486         11
             U254000012N
27485        DC   11,-46626442025,,      FLOATING SUBTRACT        15497         11
             M662644202N
27495        DC   11,-54000000235,,      MULTIPLY                 15508         11
             N400000023N
27505        DC   11,-54540000135,,      MULTIPLY IMMEDIATE       15519         11
             N454000013N
27515        DC   11,-46546453035,,      FLOATING MULTIPLY        15530         11
             M654645303N
27525        DC   11,-53440000285,,      LOAD DIVIDEND            15541         11
             N344000028N
27535        DC   11,-53445400185,,      LOAD DIVIDEND IMMEDIATE  15552         11
             N344540018N
27545        DC   11,-44000000295,,      DIVIDE                   15563         11
             M400000029N
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27555        DC   11,-44540000195,,      DIVIDE IMMEDIATE                    15574   11
             M454000019N
27565        DC   11,-46444965095,,      FLOATING DIVIDE                     15585   11
             M644496509N
27575        DC   11,-43000000245,,      COMPARE                             15596   11
             M300000024N
27585        DC   11,-43540000145,,      COMPARE IMMEDIATE                   15607   11
             M354000014N
27595        DC   11,-63440000255,,      TRANSMIT DIGIT                      15619   11
             0344000025N
27605 TDM    DC   11,-63445400155,,      TRANSMIT DIGIT IMMEDIATE            15629   11
             0344540015N
27615        DC   11,-63460000265,,      TRANSMIT FIELD                      15640   11
             0346000026N
27625        DC   11,-63465400165,,      TRANSMIT FIELD IMMEDIATE            15651   11
             0346540016N
27635        DC   11,-63465300065,,      TRANSMIT FLOATING FIELD             15662   11
             0346530006N
27645        DC   11,-63590000315,,      TRANSMIT RECORD                     15673   11
             0359000031N
27655        DC   11,-46625300055,,      FLOATING SHIFT LEFT                 15684   11
             M662530005N
27665        DC   11,-46625900085,,      FLOATING SHIFT RIGHT                15695   11
             M662590008N
27675        DC   11,-63556200725,,      TRANSMIT NUMERIC STRIP              15706   11
             0355620072N
27685        DC   11,-63554600735,,      TRANSMIT NUMERIC FILL               15717   11
             0355460073N
27695        DC   11,-42000000495,,      BRANCH                              15728   11
             M200000049N
27705        DC   11,-42554600445,,      BRANCH NO FLAG                      15739   11
             M255460044N
27715        DC   11,-42555900455,,      BRANCH NO RECORD MARK               15750   11
             M255590045N
27725        DC   11,-42440000435,,      BRANCH DIGIT                        15761   11
             M244000043N
27735        DC   11,-42630000275,,      BRANCH AND TRANSMIT                 15772   11
             M263000027N
27745        DC   11,-42635400175,,      BRANCH AND TRANSMIT IMMEDIATE       15783   11
             M263540017N
27755        DC   11,-42634653075,,      BRANCH AND TRANSMIT FLOATING FIELD  15794   11
             M263465307N
27765        DC   11,-42420000425,,      BRANCH BACK                         15805   11
             M242000042N
27775        DC   11,-42490000465,,      BRANCH INDICATOR                    15816   11
             M249000046N
27785        DC   11,-42554900475,,      BRANCH NO INDICATOR                 15827   11
             M255490047N
27795        DC   11,-52000000345,,      CONTROL                             15838   11
             N200000034N
27805        DC   11,-62460000325,,      SET FLAG                            15849   11
             0246000032N
27815        DC   11,-43460000335,,      CLEAR FLAG                          15860   11
             M346000033N
27825        DC   11,-54460000715,,      MOVE FLAG                           15871   11
             N446000071N
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27835  DC   11,-48000000485,,                HALT                              15882  11
       M800000048N
27845  DC   11,-55565700415,,                NO OPERATION                      15893  11
       N556570041N
27855  DC   11,-42480000114,,                BRANCH HIGH                       15904  11
       M248000011M
27865  DC   11,-42570000114,,                BRANCH POSITIVE                   15915  11
       M257000011M
27875  DC   11,-42450000124,,                BRANCH EQUAL                      15926  11
       M245000012M
27885  DC   11,-42690000124,,                BRANCH ZERO                       15937  11
       M269000012M
27895  DC   11,-42650000144,,                BRANCH OVERFLOW                   15948  11
       M265000014M
27905  DC   11,-42676500154,,                BRANCH EXPONENTIAL OVERFLOW       15959  11
       M267650015M
27915  DC   11,-42410000194,,                BRANCH ANY                        15970  11
       M241000019M
27925  DC   11,-42555300134,,                BRANCH NOT LOW                    15981  11
       M255530013M
27935  DC   11,-425555C0134,,                BRANCH NOT NEGATIVE               15992  11
       M255550013M
27945  DC   11,-42437100014,,                BRANCH CONSOLE SWITCH 1 ON        16003  11
       M243710001M
27955  DC   11,-42437200024,,                BRANCH CONSOLE SWITCH 2 ON        16014  11
       M243720002M
27965  DC   11,-42437300034,,                BRANCH CONSOLE SWITCH 3 ON        16025  11
       M243730003M
27975  DC   11,-42437400044,,                BRANCH CONSOLE SWITCH 4 ON        16036  11
       M243740004M
27985  DC   11,-46625962147,,                FLOATING SHIFT RIGHT SUBROUTINE   16047  11
       M662596214P
27995  DC   11,-425548C0113,,                BRANCH NOT HIGH                   16058  11
       M255480011L
28005  DC   11,-42555700113,,                BRANCH NOT POSITIVE               16069  11
       M255570011L
28015  DC   11,-42554500123,,                BRANCH NOT EQUAL                  16080  11
       M255450012L
28025  DC   11,-42556900123,,                BRANCH NOT ZERO                   16091  11
       M255690012L
28035  DC   11,-42556500143,,                BRANCH NO OVERFLOW                16102  11
       M255650014L
28045  DC   11,-42556765153,,                BRANCH NO EXPONENTIAL OVERFLOW    16113  11
       M255676515L
28055  DC   11,-42554100193,,                BRANCH NOT ANY                    16124  11
       M255410019L
28065  DC   11,-42530000133,,                BRANCH LOW                        16135  11
       M253000013L
28075  DC   11,-42550000133,,                BRANCH NEGATIVE                   16146  11
       M255000013L
28085  DC   11,-42554371013,,                BRANCH CONSOLE SWITCH 1 OFF       16157  11
       M255437101L
28095  DC   11,-42554372023,,                BRANCH CONSOLE SWITCH 2 OFF       16168  11
       M255437202L
28105  DC   11,-42554373033,,                BRANCH CONSOLE SWITCH 3 OFF       16179  11
       M255437303L
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28115          DC   11,-42554374043,,      BRANCH CONSOLE SWITCH 4 OFF          16190   11
               M255437404L
28125          DC   11,-59556368612,,      READ NUMERIC TYPEWRITER              16201   11
               N955636861K
28135          DC   11,-66556368812,,      WRITE NUMERIC TYPEWRITER             16212   11
               O655636881K
28145          DC   11,-44556368512,,      DUMP NUMERIC TYPEWRITER              16223   11
               M455636851K
28155          DC   11,-59416368712,,      READ ALPHA TYPEWRITER                16234   11
               N941636871K
28165          DC   11,-66416368912,,      WRITE ALPHA TYPEWRITER               16245   11
               O641636891K
28175          DC   11,-63426368811,,      TABULATE TYPEWRITER                  16256   11
               O342636881J
28185          DC   11,-59436368211,,      RETURN CARRAIGE TYPEWRITER           16267   11
               N943636821J
28195          DC   11,-62576368111,,      SPACE TYPEWRITER                     16278   11
               O257636811J
28205          DC   11,-46410000037,,      FLOATING ADD SUBROUTINE              16289   11
               M641000003P
28215          DC   11,-46620000027,,      FLOATING SUBTRACT SUBROUTINE         16300   11
               M662000002P
28225          DC   11,-46540000047,,      FLOATING MULTIPLY SUBROUTINE         16311   11
               M654000004P
28235          DC   11,-46440000057,,      FLOATING DIVIDE SUBROUTINE           16322   11
               M644000005P
28245          DC   11,-44496500017,,      FIXED DIVIDE SUBROUTINE              16333   11
               M449650001P
28255          DC   11,-46625859067,,      FLOATING SQUARE ROOT SUBROUTINE      16344   11
               M662585906P
28265          DC   11,-46435662077,,      FLOATING COSINE SUBROUTINE           16355   11
               M643566207P
28275          DC   11,-46624955087,,      FLOATING SINE SUBROUTINE             16366   11
               M662495508P
28285          DC   11,-46416355097,,      FLOATING ARCTANGENT SUBROUTINE       16377   11
               M641635509P
28295          DC   11,-46456763107,,      FLOATING EXPONENTIAL BASE 10 SUBROUT 16388   11
               M645676310P
28305          DC   11,-46456700117,,      FLOATING NATURAL EXPONENTIAL SUBROUT 16399   11
               M645670011P
28315          DC   11,-46535647127,,      FLOATING LOG BASE 10 SUBROUTINE      16410   11
               M653564712P
28325          DC   11,-46535500137,,      FLOATING NATURAL LOG SUBROUTINE      16421   11
               M653550013P
28335          DC   11,-46625362157,,      FLOATING SHIFT LEFT SUBROUTINE       16432   11
               M662536215P
28345          DC   11,-63465362167,,      TRANSMIT FLOATING FIELD SUBROUTINE   16443   11
               O346536216P
28355          DC   11,-42634662177,,      BRANCH AND TRANSMIT FLOATING FIELD S 16454   11
               M263466217P
28365 XDS      DC   11,44620000010,,       DEFINE SYMBOL                        16465   11
               M4620000010
28375 XDSS     DC   11,44626200110,,       DEFINE SPECIAL SYMBOL                16476   11
               M4626200110
28385 XDAS     DC   11,44416200001,,       DEFINE ALPHA SYMBOL                  16487   11
               M4416200001
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28395        DC   11,4443000C002,,          DEFINE CONSTANT                16498  11
             M4430000002
28405        DC   11,44624300102,,          DEFINE SPECIAL CONSTANT        16509  11
             M4624300102
28415        DC   11,44414300103,,          DEFINE ALPHA CONSTANT          16520  11
             M4414300103
28425 XDSA   DC   11,44624100004,,          DEFINE SYMBOLIC ADDRESS        16531  11
             M4624100004
28435 XDSB   DC   11,44624200005,,          DEFINE SYMBOLIC BLOCK          16542  11
             M4624200005
28445 XDNB   DC   11,44554200000,,          DEFINE NUMERIC BLANK           16553  11
             M4554200000
28455        DC   11,-66414344942,,         WRITE ALPHA CARD               16564  11
             O641434494K
28465        DC   11,-59414344752,,         READ ALPHA CARD                16575  11
             N941434475K
28475        DC   11,-44554344542,,         DUMP NUMERIC CARD              16586  11
             M455434454K
28485        DC   11,-66554344842,,         WRITE NUMERIC CARD             16597  11
             O655434484K
28495        DC   11,-59554344652,,         READ NUMERIC CARD              16608  11
             N955434465K
28505        DC   11,-42534300094,,         BRANCH LAST CARD               16619  11
             M253430009M
28515        DC   11,-42555343093,,         BRANCH NOT LAST CARD           16630  11
             M255534309L
28525        DC   11,44565947C06,,          DEFINE ORIGIN                  16641  11
             M4565947006
28535        DC   11,48454144008,,          HEAD                           16652  11
             M8454144008
28545        DC   11,54565947009,,          MORG                           16663  11
             N4565947009
28555        DC   11,63434400016,,          TRANSFER TO PROCESS            16674  11
             O3434400016
28565        DC   11,-63594100106,,         TRANSFER TO LOAD               16685  11
             O3594100100
28575        DC   11,-49554342187,,         INPUT CONVERSION               16696  11
             M9554342187P
28585        DC   11,-50646343007,,         OUTPUT CONVERSION              16707  11
             N0646343007P
28595        DC   11,60606060606,,          *****DUMMY OP CODE*****        16718  11
             00606060606
28605        DC   11,60606060606,,          *****DUMMY OP CODE*****        16729  11
             00606060606
28615        DC   11,60606060606,,          *****DUMMY OP CODE*****        16740  11
             00606060606
28625        DC   11,60606060606,,          *****DUMMY OP CODE*****        16751  11
             00606060606
28635        DC   11,60606060606,,          *****DUMMY OP CODE*****        16762  11
             00606060606
28645        DC   11,60606060606,,          *****DUMMY OP CODE*****        16773  11
             00606060606
28655        DC   11,60606060606,,          *****DUMMY OP CODE*****        16784  11
             00606060606
28665        DC   11,60606060606,,          *****DUMMY OP CODE*****        16795  11
             00606060606
```

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28675          DC   11,60606060606,,    *****DUMMY OP CODE*****          16806          11
               00606060606
28685 XDEND    DC   11,44455544007,,    DEFINE END                       16817          11
               M4455544007
28695 SYMTBL   DS   1                                                    16818           1
28705          DORG SYMTBL                                               16818
28715 *           ROUTINE TO FIND SIZE OF MEMORY
28725 START    TDM  0,0                                                  16818  15  00000  00000
28735 G8       TR   19999,REC1,2                                         16830  31  J9999  17036
28745          BNR  G9,0                                                 16842  45  16862  00000
28755          B    G10                                                  16854  49  16882  00000
28765          DORG *-3                                                  16862
28775 G9       AM   G8+3,20,10                                           16862  11  16833  000K0
28785          B    G8                                                   16874  49  16830  00000
28795          DORG *-3                                                  16882
28805 G10      TF   FINAL,G8+6                                           16882  26  15431  16836
28815          SM   FINAL,20                                             16894  12  15431  -0020
28825          CF   LODER1+76                                            16906  33  01372  00000
28835          CF   LODER2+76                                            16918  33  01452  00000
28845          TR   00000,STRT2                                          16930  31  00000  17038
28855 *           ROUTINE TO CLEAR INPUT AREA
28865          TF   INPUT-2,CLERER+9                                     16942  26  00795  00741
28875          TF   INPUT+10,CLERER+11                                   16954  26  00807  00743
28885          TF   INPUT+18,CLERER+7                                    16966  26  00815  00739
28895          TFM  AA3+6,INPUT+20                                       16978  16  16996  -0817
28905 AA3      TFM  ,,10                                                 16990  16  00000  000-0
28915          AM   AA3+6,2                                              17002  11  16996  -0002
28925          CM   AA3+6,INPUT+140                                      17014  14  16996  -0937
28935          BL   AA3                                                  17026  47  16990  01300
28945 REC1     DSC  2,',*-1                                              17036           2
               0'
28955 STRT2    B    INITI                                                17038  49  01798  00000
28965          DC   1,',*-4                                              17045           1
               '

28975          DEND START                                                16818
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ADDCOM	00725	A21	07250	ALFOP	03070	B65	09730	CSTAT	11726
BCMSPC	03874	A22	07384	ALPHA	00411	B66	09882	D11	13594
BRLOAD	15354	A23	07808	AORS	04010	B67	09870	D12	13818
BRRDBB	06134	A24	07852	A	15442	B68	09930	D13	14054
CASTER	02694	A25	08372	ASINE	10976	B6	02730	D14	14086
CCOMER	12966	A26	08016	ASTER	04686	B71	10228	D17	14570
CHVALD	10272	A27	08856	B10	03094	B72	10248	D18	14558
CLERER	00732	A28	08924	B12	05658	B73	10304	D19	14594
CMPCON	05754	A29	09682	B13	03802	B74	10324	D1	12754
CMPINS	06242	A2	02010	B14	03962	B75	10348	D20	14630
CMPOUT	01494	A32	10456	B15	04022	B76	10384	D21	14858
COMMER	03886	A33	10812	B16	04118	B77	10444	D22	14906
COMSPC	03906	A34	12838	B17	04182	B78	10492	D23	14954
CONSND	15280	A35	10880	B18	04218	B79	10540	D24	04966
DDINST	07956	A36	11096	B19	04374	B80	10528	D25	04990
DOLLAR	04150	A37	02546	B1	01918	B83	10832	D26	05038
DSASND	15299	A38	11714	B20	04410	B84	11084	D27	05062
ELNGTH	01264	A3	01986	B21	04562	B85	11364	D28	05014
ENTABL	01592	A41	12138	B22	04648	B87	11642	D29	05050
EPRINT	05310	A42	12402	B23	05266	B88	11630	D2	12742
ERCHAR	04274	A43	11798	B24	05246	B891	11592	D30	14738
EVALAD	03482	A44	11822	B25	05334	B89	11666	D32	14762
EVALER	05106	A45	12578	B26	05382	B8	02954	D33	04946
FLAGGR	09262	A46	12646	B27	05438	B90	12234	D34	14966
GOEVAL	13650	A47	12506	B28	05462	B91	12258	D3	12922
HEADER	05470	A48	11762	B29	05958	B92	12306	D4	13034
INPUT2	00959	A49	02966	B2	01906	B93	11914	D5	13194
INPUT3	01585	A4	02474	B30	05978	B94	11926	D6	13242
INSTRN	09030	A50	13114	B31	06098	B95	12034	D7	13278
LABCTR	14217	A51	13054	B32	06186	B96	12094	D8	13314
LINPRT	06342	A52	13206	B33	06166	B99	12614	D9	13338
LODER1	01296	A53	13442	B38	04902	B9	02186	DAC3	10680
LODER2	01376	A54	13830	B39	06634	BAKR	09550	DAC	10124
LOPOUT	01245	A55	13782	B3	02066	BBACK	04142	DAS	09974
MACROS	12434	A56	13938	B40	06714	BB	06334	DC	12710
NOPREC	00720	A57	13902	B41	06846	BETA	12413	DEND	11444
NOSINE	10600	A58	14010	B42	06906	BI	08776	DIN	12470
NOTYPE	08172	A59	14042	B45	07408	BIT	14642	DJD	12554
PCHALF	07190	A5	06274	B46	07476	BLKVR	06870	DOBI	08824
PCHCRD	06262	A60	14318	B47	07456	BLNKS	15268	DOBNI	08844
PICKUP	02984	A61	14262	B48	08252	BLSND	01457	DUDSB	06642
PNCH11	11516	A62	14450	B49	08912	BNI	08788	DODS	06678
PRDCSA	13490	A63	04934	B4	02566	BR1	10090	DOK	08994
PUNCHY	06014	A64	05722	B50	08956	BR2	10098	DOL	03823
RETURN	04058	A6	03166	B51	08968	BRNCH	06494	DORDW	08900
A10	05494	A70	13102	B52	09086	BRSO	15351	DORG	11304
A11	03862	A7	05142	B53	09178	BTBL	03424	DSA	13614
A12	03626	A8	05518	B54	09250	CHAR	09530	DSB	10764
A13	03754	A9	05506	B55	09362	CHECK	13502	DSC	13430
A14	03850	AA1	02034	B56	09294	CHKND	05222	DSDNB	11024
A15	04514	AA2	02376	B57	09406	CKREC	10066	DSS	11152
A16	06142	AA3	16990	B58	09426	CNTR	02521	EJS	00587
A17	06002	ABLE	09618	B59	09494	COLL	00618	EMPTY	05814
A18	05838	ADDRS	01122	B60	09386	COMA	05550	ER10	14678
A19	05766	AERB	13998	B61	09594	COMP	03106	ER11	04094
A1	11164	AJUST	00599	B62	09630	CONCD	05910	ER12	05678

ER13	05710	GET1	03974	MORG	11212	RECMK	01796	TSPEC	14342
ER14	14698	GET	04294	MULT	04600	RLOP	02222	TYPE	02423
ER1	02234	GOAHD	13350	NASS	11188	RMFLL	02302	WRMS	12678
ER3	03154	GOOD1	03366	NAST	02774	RMRK	01126	XDAS	16487
ER5	03778	GOOD2	03378	NOISE	14697	RSCAN	01974	XDEND	16817
ER9	14718	GOODB	03342	NUMB	00648	S1	03670	XDNB	16553
ERCON	12826	GOTO	15132	OK	03318	SEEIM	09282	XDSA	16531
ERDSA	13698	H1	02978	ONEZ	00699	SEN	10868	XDSB	16542
ERLAB	01155	HED	14341	OP	03002	SET2	13312	XDS	16465
EV1	05174	INIT2	01810	ORDER	02865	SET	13313	XDSS	16476
F1	10672	INITI	01798	OUT	00418	SFLAG	13134	ZERO	00500
F2	10704	INKRM	15082	OVER	11536	SIXTY	13337	SECINS	08416
F3	10660	INPUT	00797	PASSI	02426	SNDOP	08880	SEIFIN	04954
F9	14226	INSND	15318	PCON1	07616	SNT	11882	SEVENS	11905
FINAL	15431	INST	08764	PCON2	07748	SPAT	08592	SHEILA	11272
G10	16882	ISTAT	00689	PCON3	07796	SPEC	03930	STCHAR	10336
G11	14822	IT	04922	PCON	07520	STAR	02522	SUBENT	08542
G13	02450	JSTBL	00659	PDSA	07840	START	16818	SYMTBL	16818
G14	10058	JUST	08944	PLACE	06365	STRT2	17038	TABBY1	08524
G15	02316	K	08812	PLDR	02586	SW2	04810	TABCON	15329
G16	02878	LABL	03825	PNCH1	02438	SYM1	11962	TBLCRD	14998
G17	02898	LABOK	04878	PRDAS	08752	SYM2	11986	TBLEND	04353
G18	02910	LAB	01261	PRDSR	11012	TABBY	08548	TESTAD	13217
G19	02834	LBADD	04830	PRDS	11176	TDM	15629	THINGS	00641
G1	11328	LBLOK	14462	PRSW	08664	TEMPR	00730	TISTAT	15113
G20	02090	LDMED	14498	PRSYM	11786	TEMP	00406	TRNUM1	04526
G22	06574	LDLBL	14194	PRT1	06438	TEST3	04742	TRNUMB	04442
G23	02258	LINE	06502	PRT2	06458	TEST	08530	TYPADD	08611
G24	03258	LINK	01128	PTBL	12210	TFADD	04766	TYPDSA	07360
G25	08572	LNTH	00704	RC2	08702	TOBB	04130	TYPINS	09214
G26	02990	L	11559	RCNT	08709	TRAC	01294	WRPRND	05402
G30	11894	LYNN	11248	RCTY1	08654	TRANS	09374	ZERONE	09650
G4	04286	MAC1	09750	RCTY	08618	TRA	14146		
G5	08580	MACRO	09670	RDW	08800	TRDSA	13890		
G8	16830	MESS1	01171	READ	02634	TRREC	13090		
G9	16862	MESS2	01201	REC1	17036	TR	05862		

END OF ONE ASSEMBLY.